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ADVERTISEMENT.

In presenting to the Public the First Number of the Quarterly Journal of Science and the Arts, the Editors have deemed it useless to descant upon the utility of periodical publications, in facilitating the progress and diffusion of philosophy, and in benefiting the arts by furnishing a channel by which insulated facts and opinions may be added to the common stock of knowledge and experience. These advantages are duly estimated by scientific men, and by the public at large.

Nor is it needful to enter at any length into the circumstances which have especially suggested the present work; for it is rather wished that the scientific public should build their opinion, upon the intent and spirit of the undertaking, by the inspection of the work, than found their expectations of its novelty and merits upon the suggestions of a prospectus, or the promises of an

advertisement. It seems only requisite, therefore, on the present occasion, briefly to sketch the outline of the design.

The permanent records of Science are chiefly preserved in the Transactions of learned Societies; and are principally confined to the labours of their Members only. The monthly publications, edited by individuals, furnish an account of what may be regarded as the News of Philosophy. It is proposed that the present JOURNAL shall appear only four times a year; and in this period of activity in Science and Literature, it may be presumed that a sufficiency of useful information respecting the Sciences and the Arts of Life may be collected, to give interest and importance to a quarterly publication. The circumstances of the times likewise are favourable; the great Commonwealth of Europe is recovering its ancient social relations; and it may be hoped that those energies of the human mind which have so long been employed in the operations of War, will be turned to the Arts of Peace, and that enterprise and emulation will principally be directed to objects connected with the happiness of society.

It will be the earnest endeavour of the Editors to fulfil the objects of the Quarterly Journal of Science and the Arts, according to the most

legitimate precepts, and in the true spirit of Philosophical Literature. They will candidly present to the public every useful discovery, and every promising novelty; confining themselves principally to those objects of experiment which form a permanent part of Science, and to discussions which lead to new experiments; and without presuming either to dispense commendation or convey censure, will endeavour to assist the reader in discriminating the true from the false, and the shadow from the reality.

Among those who have already undertaken to contribute to, and otherwise support the present work, are not only many of the most active Members of the Royal Institution, but several Gentlemen of scientific and literary eminence, resident in different parts of the kingdom: and it is earnestly expected, that when these intentions are known, and above all, when the promises here made shall have been verified by the first publication, that others will lend assistance to an undertaking, which, it may be hoped, will enhance the reputation of British Science. The ROYAL INSTITUTION appears a proper point whence a work like the present should emanate. The list of Members contains Names celebrated throughout Europe for high literary and scientific attainments; and the Establishment possesses many important requi-

sites, among which may be enumerated a copious and valuable Library, a Geological and Mineralogical Collection, and a Laboratory well adapted for the prosecution of experimental research, and which has already contributed most essentially to the progress of Chemical knowledge.

April, 1816.

☞ It is requested that all communications for this work may be forwarded to Mr. Brande, at the Royal Institution.

THE QUARTERLY JOURNAL

OF

SCIENCE AND THE ARTS

ART. I. *On the Wire-gauze Safe-lamps for preventing Explosions from Fire-damp, and for giving Light in explosive Atmospheres in Coal Mines. By Sir* H. DAVY, *LL.D. V.P.R.I. F.R.S. L. and E. &c.*

THE dreadful accidents of explosions which occur in coal mines, are occasioned by the firing of light carburetted inflammable gas which is disengaged during the working of the coals, and from fissures in the strata, and which, when it has accumulated in any place in the mine so as to form more than $\frac{1}{13}$ part of the volume of the atmospherical air, becomes explosive by a lighted candle, or by any kind of flame.

In parts of the mine where danger is apprehended from the fire-damp, the miners have been accustomed to guide themselves, or to work, by the light afforded by the sparks of steel struck off from a wheel by flint; but even this apparatus, though much less dangerous than a candle, sometimes produces explosions of the fire-damp.

A perfect security from accident is, however, offered to the miner in the use of a safe-lamp, which transmits its light, and is fed with air through a cylinder of wire-gauze; and this invention has the advantage of requiring no machinery, no philosophical knowledge to direct its use, and is made at a very cheap rate.

In the course of a long and laborious investigation on the properties of the fire-damp, and the nature and communication of flame, I ascertained that the explosions of inflammable gases were incapable of being passed through long narrow metallic tubes; and that this principle of security was still obtained by diminishing their length and diameter at

the same time, and likewise diminishing their length and increasing their number, so that a great number of small apertures would not pass explosion when their depth was equal to their diameter. This fact led me to trials upon sieves made of wire-gauze, or metallic plates perforated with numerous small holes; and I found that it was impossible to pass explosions through them. I have detailed the progress of these researches, and endeavoured to explain the principle of the operation of flame sieves, in some papers read before the Royal Society. My object in this communication is, to offer a few practical hints to the proprietors and inspectors of mines, and to the miners who may make use of the lamp.

The apertures in the gauze should not be more than $\frac{1}{20}$ of an inch square. As the fire-damp is not inflamed by ignited wire, the thickness of the wire is not of importance, but wire* from $\frac{1}{40}$ to $\frac{1}{60}$ of an inch in diameter is the most convenient.

Iron wire and brass wire gauze of the required degree of fineness, are made for sieves by all wire workers; and except when a lamp is to be used by a viewer for dialling, iron wire gauze is to be preferred: when of the proper degree of thickness it can neither melt nor burn; and the coat of black rust which soon forms upon it superficially, defends the interior from the action of the air.

The cage or cylinder should be made by double joinings, the gauze being folded over in such a manner as to leave no apertures. When it is cylindrical, it should not be more than 2 inches in diameter; for in larger cylinders the combustion of the fire-damp renders the top inconveniently hot; and a double top is always a proper precaution, fixed at the distance of $\frac{1}{2}$ or $\frac{3}{4}$ of an inch above the first top.

The gauze cylinder should be fastened to the lamp by a screw of four or five turns, and fitted to the screw by a tight ring. All joinings in the lamp should be made with hard solder; and the security depends upon the circumstance, that

* If the wire of $\frac{1}{40}$ is found to wear out too soon in practice, the thickness may be increased to any extent; but the thicker the wire, the more the light will be intercepted, for the size of the apertures must never be more than $\frac{1}{20}$ of an inch square. In the working models which I have sent to the mines, there are 748 apertures in the square inch.

no aperture exists in the apparatus larger than in the wire gauze.

The forms of the lamp and cage, and the mode of burning the wick, may be greatly diversified; but the principle which ensures their safety must be strictly attended to. A wire gauze cylinder which fits tight on the lamp like the cover of a box, is less safe than one attached to a screw, because it may be bent so as to leave an unsafe aperture, and two turns of a screw only gives more security.

Fig. 1. represents a wire-gauze safe-lamp of exactly half the length and breadth of a working lamp.*

A. the cistern which contains the oil.

B. the rim in which the wire-gauze cover is fixed, and which is fastened to the cistern by a moveable screw.

C. an aperture for supplying oil, fitted with a screw or a cork, and which communicates with the bottom of the cistern by a tube.

D. the receptacle for the wick.

E. a wire for raising, lowering, or trimming it, and which passes through a safe tube.

F. the wire gauze cylinder, which should not have less than 625 apertures to the square inch.

G. the second top $\frac{3}{4}$ of an inch above the first.

H. a copper plate, which may be in contact with the second top.

I. I. I. I. thick wires surrounding the cage to preserve it from being bent.

K. K. are rings to hold or hang it by.

When the wire-gauze safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms as much as $\frac{1}{12}$ of the volume of the air, the cylinder becomes filled with a feeble blue flame, but the flame of the wick appears burning brightly within the blue flame, and the light of the wick continues till the fire damp increases to $\frac{1}{6}$ or $\frac{1}{5}$, when it is

* These instruments are made and sold by Mr. Newman, mathematical instrument maker, 7, Lisle-street, London.

lost in the flame of the fire damp, which in this case fills the cylinder with a pretty strong light.* As long as any *explosive* mixture of gas exists in contact with the lamp, so long it will give light, and when it is extinguished, which happens when the foul air constitutes as much as $\frac{1}{3}$ of the volume of the atmosphere, the air is no longer proper for respiration; for though animal life will continue where flame is extinguished, yet it is always with suffering.

In cases in which the fire-damp is mixed only in its smallest explosive proportion with air, the use of the wire-gauze safe-lamp, which rapidly consumes the inflammable gas, will soon reduce the quantity below the explosive point; and it can scarcely ever happen that a lamp will be exposed to an explosive mixture containing the largest proportion of fire-damp; but even in this case the instrument is absolutely safe; and should the wires become red hot, they have no power of communicating explosion.

I have exposed lamps to much more severe trials than they can ever experience in collieries, passing through them currents of the most explosive mixtures of gas from the distillation of coal, which is much more inflammable than the fire-damp, and air; and I have even surrounded them with an explosive atmosphere containing thrice as much oxygen as common air; and though the wire sometimes became strongly red hot, yet no explosion ever took place. It must, however, be understood, that this last and most severe trial was made on wire-gauze having 900 apertures to the square inch.

Should it ever be necessary for the miner to work for a great length of time in an explosive atmosphere by the wire-gauze safe-lamp, it may be proper to cool the lamp occasionally by throwing water upon the top, or a little cistern for holding water may be attached to the top, the evaporation of which will prevent the heat from becoming excessive.

When the fire-damp is burning in the cylinder, the flame

* In approaching a blower, or an aperture from which fire-damp is disengaged, all these appearances are perceived; and Mr. Buddle informs me, that in the foul parts of workings, he produced the different states of the flame by raising or lowering the safe-lamp, the inflammable gas being much larger in quantity toward the roof of the mine.

may be easily extinguished by putting a cap of metal, or even woollen or linen over it.

The iron wire-gauze cylinders when in use will not be found to rust, and when they are laid aside for any time they should be oiled; and their safety should be proved before they are used, by plunging them into a jar or a barrel containing an explosive mixture of fire-damp.

By obliging the miners always to use wire-gauze safe-lamps in those parts of coal mines liable to fire-damp, explosions will be rendered impossible. Persons appointed by the viewers should daily inspect the lamps, and supply them with oil; and to prevent the possibility of accidents from the removal of the gauze cylinders, they may be fastened to the lamps by small padlocks; though as the imminent danger arising from such a circumstance is obvious, the precaution, it may be hoped, will be unnecessary.

There are persons who always undervalue the resources of Science, and who endeavour to lessen the importance of any benefit conferred upon humanity: such persons have thought proper to suppose, that in the actual trials of the lamps in the mines, unforeseen difficulties and dangers may occur. I am happy, however, to be able to state, that they have been tried in the most dangerous mines in the neighbourhood of Newcastle and Whitehaven, which are the most dangerous in Great Britain, with the greatest success; and to the perfect satisfaction, as well as astonishment, of the miners. And now that the adoption of them is urged by such enlightened practical men as Mr. Buddle and Mr. Peele, they can hardly fail of being generally used in all collieries liable to fire-damp. And there is every reason to expect that they will secure the lives of a most useful class of men, relieve their families from anxiety, remove a great weight of responsibility from the mine agent, and diminish considerably the expenditure of the coal owner.*

* The principle may be applied to many other uses. The safe-lamps will prevent accidents in gas manufactories, spirit manufactories and warehouses, and in all places where gaseous inflammable matter is likely to be disengaged; and for the common purposes of light, they will always prevent danger from sparks as well as *flame*.

Grosvenor-street, Feb. 25, 1816.

Art. II. *Demonstrations of some of Dr. Matthew Stewart's General Theorems; to which is added, an Account of some new Properties of the Circle.* By Charles Babbage, *Esq.*

Nearly seventy years have elapsed since Dr. Matthew Stewart published, under the title of General Theorems, a series of geometrical propositions of singular difficulty and elegance. Many of them are capable of forming, with a slight alteration in the enunciation, the most beautiful porisms: and these, as it is well known, constitute a class of propositions invented by the ancients, and which formed a valuable part of their analysis; but the name alone remained to us until their re-discovery by Dr. Simson, which may rival, in point of difficulty, any of the investigations of the celebrated geometers of antiquity. The means by which Dr. Stewart arrived at these theorems he never made public, nor does it appear that any traces of them have been found among his papers. Several geometers have applied themselves to this subject: Dr. Small gave demonstrations of those which relate to the squares of given lines; these are to be found in the Second Volume of the Transactions of the Royal Society of Edinburgh; and in the Fifth Volume of the same work are some very elegant properties of the circle by Mr. Glenie, from which he deduces demonstrations of many of those which relate to regular figures.

In both the papers to which I have alluded, the geometrical method of investigation is employed; and perhaps, on the whole, it may be thought best adapted to the nature of the subject. Other proofs, however, derived from other principles, may not be uninteresting, not as adding any thing to the evidence on which these propositions rest, but as furnishing us with the means of comparing the extent and power of the two modes of reasoning made use of in their demonstration.

With this view I shall, in the following Paper, deduce from the principles of common algebra and trigonometry, the proofs of a considerable number of these theorems, and I shall,

at its conclusion, offer some new theorems which have occurred to me in similar investigations; thus endeavouring to prove that analysis is equally adapted for the demonstration of propositions which may be known, and for the discovery of those which are unknown, even in a branch of enquiry which has hitherto been treated by methods purely geometrical.

For the sake of convenience I shall premise two or three lemmas, but as they contain little that is new, I shall merely indicate the means by which they may be proved.

LEMMA I.

$$\cos \theta + \cos (\theta + b) + \cos (\theta + 2b) + \&c. + \cos (\theta + \overline{p-1}\, b)$$
$$= \frac{\cos\left(\theta + \frac{b}{2}\right) \sin. \frac{p}{2} b}{\sin. \frac{b}{2}}.$$

and

$$\sin \theta + \sin (\theta + b) + \sin (\theta + 2b) + \&c. + \sin (\theta + \overline{p-1}\, b$$
$$= \frac{\sin\left(\theta + \frac{b}{2}\right) \sin \frac{p}{2} b}{\sin. \frac{b}{2}}$$

these formulæ are well known and readily proved; let us now suppose a circle divided into p equal parts, and let $b = \frac{2\pi}{p}$. If θ express any angle whatever, and if we constantly add to it the p^{th} part of the circumference until we have gone round the circle, then will the sum of all the cosines of these arcs and also the sum of all the sines of the same arcs be equal to zero. This will be evident by substituting the value of b in the above expressions. We have therefore,

$$o = \cos \theta + \cos \left(\theta + \frac{2\pi}{p}\right) + \&c. + \cos \left(\theta + \overline{p-1}\, \frac{2\pi}{p}\right)$$

$$o = \sin \theta + \sin \left(\theta + \frac{2\pi}{p}\right) + \&c. + \sin. \left(\theta + p - 1\, \frac{2\pi}{p}\right)$$

LEMMA II.

$$(\cos\,\theta)^q + \left(\cos\,\overline{\left(\theta + \frac{2\pi}{p}\right)}\right)^q + \left(\cos\,\overline{\theta + 2\,\frac{2\pi}{p}}\right)^q + \&c.$$

$$+ \left(\cos\,\theta + p - 1\,\frac{2\pi}{p}\right)^q = o$$

$$(\sin\,\theta)^q + \left(\sin\,\theta + \frac{2\pi}{p}\right)^q + \left(\sin\,\theta + 2\,\frac{2\pi}{p}\right)^q + \&c.$$

$$+ \left(\sin\,\theta + \overline{p-1}\,\frac{2\pi}{p}\right)^q = o$$

whenever q is an odd number.

Each term of the first series may be developed according to simple powers of the cosine of the arc and its multiples, and if these developements be arranged under each other, it will be found that the sum of each vertical column is, by the preceding lemma, equal to zero, consequently the whole series is equal to zero.

Again, each term of the second series may be developed according to the simple powers of the sine of the arc and its multiples, and these being arranged under each other, it will be found, from the first lemma, that the sum of each vertical column is equal to zero.

LEMMA III.

$$(\cos\,\theta)^q + \left(\cos\,\overline{\theta + \frac{2\pi}{p}}\right)^q + \left(\cos\,\overline{\theta + 2\,\frac{2\pi}{p}}\right)^q + \&c.$$

$$+ \left(\cos\,\overline{\theta + \overline{p-1}\,\frac{2\pi}{p}}\right)^q = \frac{p}{2^q}\;\frac{q \cdot q-1 \ldots \frac{q}{2}+1}{1 \cdot 2 \ldots \frac{q}{2}}$$

and

$$(\sin\,\theta)^q + \left(\sin\,\theta + \frac{2\pi}{p}\right)^q + \left(\sin\,\overline{\theta + 2\,\frac{2\pi}{p}}\right)^q + \&c.$$

$$+ \left(\sin\,\overline{\theta + \overline{p-1}\frac{2\pi}{p}}\right)^q = \frac{p}{2^q} \cdot \frac{q \cdot q - 1 \ldots \frac{q}{2} + 1}{1 \cdot 2 \ldots \frac{q}{2}}$$

when q is an even number.

The proof for this lemma is similar to that for the last, except that in each developement there will be found a constant term of the form $\frac{1}{2^q} \cdot \frac{q \cdot q-1 \,.\,.\, \frac{q}{2}+1}{1\,.\,2\,.\,.\,.\,.\,\frac{q}{2}}$ which contains neither sine nor cosine, and as there are p terms in the series, its sum will be equal to p times this term as it is given above.

By means of these two lemmas we may demonstrate many of Dr. Stewarts theorems with great brevity. I shall begin with the 39th proposition, as it contains several of those which precede it; it is as follows:

"Let there be any regular figure circumscribed about a circle, and let the number of the sides be m, and let n be any number less than m; let r be the radius of the circle; and from any point in the circumference of the circle let there be drawn perpendiculars to the sides of the figure: the sum of the n^{th} powers of the perpendiculars will be equal to

$$m \times \frac{1\,.\,3\,.\,5\,.\,.\,.\,2n-1}{1\,.\,2\,.\,3\,.\,.\,.\,n}\, r^n$$

Fig. I. Let AE and EF be two sides of any regular polygon circumscribed about a circle, and draw the perpendiculars CD, CF from the centre, let P be any point in the circumference of the circle, and from it draw perpendiculars to all the sides of the polygon, and also to the lines CD and CF, and let the angle PCD be called θ. Now since the figure is a regular polygon of m sides, the angle DCF is equal to $\frac{2\pi}{m}$, and the same angle is contained between any two perpendiculars drawn to two adjacent sides. We have for the perpendiculars

$$PA = KD = r - r\cos\theta,\quad PB = r - r\cos\overline{\theta + \frac{2\pi}{m}},\ \&c.$$

$$\text{or } PA = r\,(1-\cos\theta) = 2r\left(\sin\frac{\theta}{2}\right)^2,\ PB = 2r\left(\sin\frac{1}{2}\,\theta + \frac{2\pi}{m}\right)^2,\ \&c.$$

consequently the sum of the n^{th} powers of the perpendiculars is equal to

$$2^n r^n \left\{ \left(\sin\frac{\theta}{2}\right)^{2n} + \left(\sin\frac{1}{2}\overline{\theta + \frac{2\pi}{m}}\right)^{2n} + \left(\sin\frac{1}{2}\overline{\theta + 2\frac{2\pi}{m}}\right)^{2n} + \&c. + \left(\sin\frac{1}{2}\overline{\theta + \overline{m-1}\frac{2\pi}{m}}\right)^{2n}\right.$$

by combining together Lemmas I. and III. this expression may readily be proved to be equivalent to

$$2^n r^n \left\{ \frac{m}{2^{2n}} \cdot \frac{2n \,.\, \overline{2n-1} \ldots \overline{n+1}}{1 \,.\, 2 \ldots n} \right\} = \frac{mr^n}{2^n} \cdot \frac{2n \,.\, \overline{2n-1} \ldots \overline{n+1}}{1 \,.\, 2 \ldots . n}$$

this expression will become the same as that given by Dr. Stewart if we can prove that $\frac{2n.\overline{2n-1}..\overline{n+1}}{2^n} = 1.3.5...\overline{2n-1}$

which may be thus effected,

$$1 \,.\, 2 \,.\, 3 \ldots . 2n = 1 \,.\, 3 \,.\, 5 \ldots \overline{2n-1} \times 2 \,.\, 4 \,.\, 6 \ldots 2n$$
$$= 1 \,.\, 3 \,.\, 5 \ldots \overline{2n-1} \times 1 \,.\, 2 \,.\, 3 \ldots n \times 2^n$$

and by dividing by $1 \,.\, 2 \,.\, 3 \ldots n \times 2^n$ we have

$$\frac{\overline{n+1} \,.\, \overline{n+2} \ldots 2n}{2^n} = 1 \,.\, 3 \,.\, 5 \ldots \overline{2n-1}$$

consequently the sum of the n^{th} powers of the perpendiculars drawn to the sides of the figure, is equal to

$$m\, r^n \frac{1 \,.\, 3 \,.\, 5 \ldots \overline{2n-1}}{1 \,.\, 2 \,.\, 3 \ldots n}$$

If $n=3$ this becomes the 22d prop. which is, that twice the sum of the cubes of the perpendiculars drawn from any point in the circumference of a circle to the sides of the circumscribed regular polygon, is equal five times the cube of the radius of the circle multiplied by the number of sides of the figure.—

If $n=4$, it becomes prop. 28.

The next proposition I shall demonstrate is the 41st; it is as follows:

" Let there be any regular figure inscribed in a circle, and let the number of its side be m; and let n be any number less than m, and let r be the radius of the circle, and from all the angles of the figure let there be drawn right lines to any point in the circumference; then the sum of the $2n^{th}$ powers of these chords will be equal to $m \times \frac{1 \,.\, 3 \,.\, 5 \ldots \overline{2n-1}}{1 \,.\, 2 \,.\, 3 \ldots n} \times 2^n r^{2n}$."

Let θ be the angular distance of any point in the circumference from the next angular point, then $\theta + \frac{2\pi}{m}$ will be its distance from the point beyond, and $\theta + 2\frac{2\pi}{m}$ will be its distance from the next beyond and so on; and since the chord is equal to twice the sine of half the arc, the sum of the $2n^{th}$ powers of the chords will be equal to

$$(2r)^{2n}\left\{\left(\sin\frac{\theta}{2}\right)^{2n} + \left(\sin\frac{1}{2}\overline{\theta+\frac{2\pi}{m}}\right)^{2n} + \left(\sin\frac{1}{2}\overline{\theta+2\frac{2\pi}{m}}\right)^{2n} + \&c. + \left(\sin\frac{1}{2}\overline{\theta+\overline{m-1}\,\frac{2\pi}{m}}\right)^{2n}\right\}$$

and his expression may by means of the first and third lemma be shown to be equal to

$$(2r)^{2}\left\{\frac{m}{2^{2n}}\cdot\left\{\frac{2n\,.\,2n-1\,.\,.\,.\,n+1}{1\,.\,2\,.\,3\,.\,.\,.\,n}\right\}\right\}$$

which becomes, since $2n\,.\,2n-1\ldots n+1 = 1.3.5\ldots\overline{2n-1}\times 2^n$

$$2^{2n}\,r^{2n}\left\{\frac{m}{2^{2n}}\cdot\frac{1.3.5\ldots\overline{2n-1}}{1.2.3\ldots n}2^n\right\} = m\,2^n\,r^{2n}\,\frac{1.3\,5\ldots\overline{2n-1}}{1.2.3\ldots n}$$

If $n=2$ we have the following theorem, which is prop. 26,

Q.E.D.

"Let there be any regular polygon inscribed in a circle, and from all the angles of the figure, let lines be drawn to any point in the circumference. Then the sum of the fourth powers of the chords will be equal to six times the fourth power of the radius of the circle multiplied by the number of sides of the polygon."

The 40th prop. of the General Theorems is as follows:

Let there be any regular figure circumscribed about a circle, and let m be the number of sides, and let n be any number less than m, and let r be the radius of the circle; and from any point within the figure let there be drawn perpendiculars to the sides, and likewise a line to the centre of the circle: let a be the co-efficient of the third term of a binomial raised to the power n, b the co-efficient of the fifth term, c the co-efficient of the seventh, and so on: and then the sum of the n^{th} powers of the perpendiculars will be equals

to $m \times \left\{ r^n + a\frac{1}{2}v^2 r^{n-2} + b\frac{1.3}{2.4}v^2 r^{n-4} + c\frac{1.3.5}{2.4.6} v^b r^{n-6} + \&c. \right\}$
which may be thus proved.

Fig. II. Let AB be one of the sides of the polygon, and P any point within it. Conceive perpendiculars drawn to each side of the polygon from the centre of the circle, and from the point P, and let the angular distance of the line $CP = v$, from the perpendicular CD be called θ, then it will appear from inspection, that the perpendicular from the point P, on the side AB, is equal to $r - v \ cos. \ \theta$, and since the angular distance of the line CP, from the perpendicular drawn from the centre to the side next to AB will be $\theta + \frac{2\pi}{m}$, the perpendicular drawn from P to that side will be $r - v \cos. \overline{\theta + \frac{2\pi}{m}}$ and similarly for the other perpendiculars.

If, therefore, we arrange the n^{th} powers of these perpendiculars under each other, we have

$$r^n - \frac{n}{1} r v^{n-1} \cos\theta + \frac{n.n-1}{1.2} r^{n-2} v^2 (\cos\ \theta)^2 - \frac{n.n-1.n-2}{1.2.3} r^{n-3} v^3 (\cos\theta)^3 + \&c.$$

$$r^n - \frac{n}{1} r^{n-1} v \cos\overline{\theta + \frac{2\pi}{m}} + \frac{n\,.\,n\ \ 1}{1.2} r^{n-2} v^2 \left(\cos\ \overline{\theta + \frac{2\pi}{m}}\right)^2 - \frac{n\,.\,n-1\,.\,n-2}{1\,.\,2\,.\,3} r^{n-3} v^3 \left(\cos\ \overline{\theta + \frac{2\pi}{m}}\right)^3 + \&c.$$

&c. &c. &c.

$$\frac{n}{1} r^{n-1} v \left(\cos\overline{\theta + \overline{m-1}\frac{2\pi}{m}}\right) + \frac{n\,.\,n-1}{1\,.\,2} r^{n-2} v^2 \left(\cos\theta + \overline{m-1}\frac{2\pi}{m}\right)^2 - \frac{n.n-.n-2}{1\,.\,2\,.\,3} r^{n-3} v^3 \left(\cos\ \overline{\theta + \overline{m-1}\frac{2\pi}{m}}\right)^3 + \&c.$$

All the even vertical columns vanish by Lemma II. and if we take the sum of the odd ones by Lemma III. we have

$$m\left\{ r^n + \frac{n.n-1.2.1}{1.2\ \ 1.2} v^2 r^{n-2} + \frac{n\,.\,n-1\,.\,n-2\,.\,n-3}{1\,.\,2\,.\,3\,.\,4}\cdot\frac{4.3}{1.2}\cdot\frac{1}{2^2} v^4 r^{n-4} + \&c. \right\}$$

and since $\frac{2p \,.\, 2p-1 \,.\,.\, p-1}{1 \,.\, 2 \,.\,.\,.\, p} = \frac{1 \,.\, 3 \,.\, 5 \,.\,.\, 2p-1}{2 \,.\, 4 \,.\, 6 \,.\,.\,.\, 2p}$ the expression becomes

$$m\left\{r^n + a\frac{1}{2}\,r^{n-2}\,v^2 + b\frac{1.3}{2.4}r^{n-4}v^4 + c\frac{1.3.5}{2.4.6}r^{n-6}\,v^6 + \&c.\right\}$$

which is the one given in the problem. Q. E. D.

When $n=3$ this becomes Prop. 23.

And when $n=4$ it is Prop. 29.

Prop. 42 is as follows:

"Let there be any regular figure inscribed in a circle, and let m be the number of sides, and n any number less than m; and from all the angles of the figure, and from the centre of the circle, let there be drawn lines to any point; and let r be the radius of the circle, and v the line drawn to the centre; then the sum of the $2n^{th}$ powers of the lines drawn to the angles of the figure will be equal to

$$m\left\{r^{2n} + \left(\frac{n}{1}\right)^2 v^2\,r^{2n-2} + \left(\frac{n.n-1}{1.2}\right)^2 v^4\,r^{2n-4} + \left(\frac{n.n-1.n-2}{1.2.3}\right)^2 v^6\,r^{2n-6} + \&c.\right\}"$$

which may thus be demonstrated.

Fig. III. Let lines be drawn to the angles of the figure and to the point P from the centre of the circle, and let the line $CP=v$ make the angle θ with the first of the lines drawn from the centre to the angular points, then by inspecting the figure, it will readily appear that the square of the line drawn from P to the angle A will be equal to r^2+v^2-2 or cos. θ, and the angular distance of the line CP from the next angle being $\theta + \frac{2\pi}{m}$ the square of the line drawn to that point will be

$$r^2 + v^2 - 2\,vr\cos\overline{\theta + \frac{2\pi}{m}}$$ and so on: hence the sum of the $2n^{th}$ powers of these lines will be

$$(r^2 + v^2 - 2\,rv\,\cos\theta)^n + \overline{r^2 + v^2 - 2,\,vr\cos\theta + \frac{2\pi}{m}}\Big)^n + \&c. + \left(r^2 + o^2 - 2\,vr\cos\overline{\theta + m-1\,\frac{2\pi}{m}}\right)$$

and if this expression be arranged in vertical columns, and if

the value of those series which contain cosines of arcs be substituted from Lemmas II. and III. the result will be

$$(r^2+v^2)^n + \frac{n.n-1}{1.2}(vr)^2(r^2+v^2)^{n-2}.\frac{2}{1} + \frac{n.n-1.n-2.n-3}{1.2.3.4}$$
$$(rv)^4(r^2+v^2)^{n-4}\frac{4.3}{1.2} + \frac{n\,.\,n-1\,...\,n-5}{1\,.\,2\,...\,6}(rv)^6(r^2+v^2)^{n-6}$$
$$\frac{6.5\,4}{1.2.3} + \&c.$$

The next step will be to arrange this series according to the powers of v^2 and r^2 for which purpose we will find the value of the co-efficient of $v^{2q}\,r^{2n-2q}$ which is

$$\frac{n\,.\,n-1\,...\,n-q+1}{1\,.\,2\,...\,q} + \frac{n\,.\,n-1}{1^2}\cdot\frac{n-2\,.\,n-3\,...\,n-q}{1\,.\,2\,...\,q-1}$$
$$+\frac{n\,.\,n-1\,.\,n-2\,.\,n-3}{1^2\,.\,2^2}\cdot\frac{n-4\,...\,n-q-1}{1\,.\,2\,..\,q-2} + \&c.$$
$$=\frac{n\,.\,n-1\,...\,n-q+1}{1\,.\,2\,...\,q}\left\{1+\frac{n-q}{1}\cdot\frac{q}{1}+\frac{n-q\,.\,n-q-1}{1\,.\,2}\cdot\right.$$
$$\frac{q\,.\,q-}{1\,.\,}$$

Now the series within the braces is equal to the co-efficient of that term which does not contain x in the product of the two series

$$(1+x)^{n-q} = 1+\frac{n-q}{1}x+\frac{n-q\,.\,n-q-1}{1\,.\,2}x^2+\&c.$$
$$\left(1+\frac{1}{x}\right)^q = 1+\frac{q}{1}\,\frac{1}{x}+\frac{q\,.\,q-1}{1\,.\,2}\,\frac{1}{x^2}+\&c.$$

which is equal to that term which does not contain x in the developement of $\frac{(1+x)^n}{x^q}$ which is equal to

$$\frac{n\,.\,n-1\,....\,n-q+1}{1\,.\,2\,.\,3\,...\,q}$$

consequently the coefficient of $v^{2q}\,r^{2n-2q}$ is

$$\left(\frac{n\,.\,n-1\,....\,n-q+1}{1\,.\,2\,...\,q}\right)^2$$

and the series given as above when arranged according to the powers of v^2 and r^2 will assume the form

$$r^{2n}+\left(\frac{n}{1}\right)^2 v^2\,r^{2n-2}+\left(\frac{n.n-1}{1.2}\right)^2 v^4\,r^{2n-4}+\left(\frac{n\,.\,n-1\,.\,n-2}{1\,.\,2\,.\,3}\right)^2$$
$$v^6\,r^{2n-6}+\&c.$$

which is the same as that given by Dr. Stewart.

if $n = 2$ this becomes Prop. 27.

Prop. 45, is as follows:

"Let there be any number of right lines intersecting each other in a point, and making all the angles round the point of intersection equal; let m be the number of the lines, and let n be any number less than m, and from any point let there be drawn perpendiculars to the right lines, and also a line to the point of intersection; let v be the line drawn to the point of intersection, the sum of the $2n^{th}$ powers of the perpendiculars drawn to the right lines will be equal to

$$m \times \frac{1\,.\,3\,.\,5\ldots \overline{2n-1}}{1\,.\,2\,.\,3\ldots n} \cdot \frac{v^{2n}}{2^n}\text{"}$$

which may readily be proved thus.

Fig. IV. C being the point where all the lines meet, and P the point from which the perpendiculars are drawn, let the angular distance of the line CP $= v$ from the line CA be called θ, and its angular distance from the next line will be $\theta + \frac{2\pi}{m}$ and so on, consequently the perpendiculars from the point P, will be represented by $v \sin \theta$, $v \sin \overline{\theta + \frac{2\pi}{m}}$, &c. and the sum of their $2n^{th}$ powers will be

$$v^{2n}\left\{ (\sin\theta)^{2n} + \left(\sin \overline{\theta + \frac{2\pi}{m}}\right)^{2n} + \&c. + \left(\sin \overline{\theta + \overline{m-1}\,\frac{2\pi}{m}}\right)^{2n} \right\}$$

which by Lemma III. is equal to

$$v^{2n} \times \frac{m}{2^{2n}} \cdot \frac{2n\,.\,\overline{2n-1}\ldots n+1}{1\,.\,2\,.\,3\ldots n} = v^{2n}\,\frac{m}{2^{2n}}\,\frac{1\,.\,3\,.\,5\,.\,.\,\overline{2n-1}\,.\,2^n}{1\,.\,2\,.\,3\ldots n}$$

$$= m\,\frac{v^{2n}}{2^n}\,\frac{1\,.\,3\ldots\ldots 2n-1}{1\,.\,2\,.\,3\ldots n}$$

In the case of $n=2$ this becomes Prop. 34.

The general theorems may be divided into three classes, 1st, Those which relate to regular figures, or to lines making equal angles with each other round a point; 2nd, Those which relate to lines drawn parallel to each other, or which all meet in a point; and, 3d, Those which relate to lines and figures irregularly drawn.

The first class, or those which relate to regular figures and lines making equal angles with each other, may, I believe,

all be demonstrated by means of the three lemmas at the commencement of this paper; and, by the same means, many other properties of regular polygons may be deduced. Of the manner of proving the second class, which relate to lines parallel to each other, or cutting each other in a point, I shall offer a few examples in the succeeding pages. The demonstrations of the third class, namely, of those which relate to irregular figures, appear to depend on other principles.

Prop. 54 is as follows:

"Let there be any number of right lines given in position, and parallel to each other; and let n be any given number; and from a point let there be drawn right lines in given angles to all the right lines given by position; and let the sum of the n^{th} powers of the lines drawn to the given angles be invariable: and the point from which the lines are drawn will be in a line given by position."

Let the equations of the given lines which are parallel be $y' = x' \tan. a + b$ $\;y' = x' \tan. a + b_1$ $\;y' = x' \tan. a + b_2$, &c.

and x and y being the co-ordinates of the point from which the lines are drawn, let θ, θ_1, θ_2, &c. be the angles these lines form with the perpendiculars to the given lines. Now it is well known that the length of a perpendicular from the point whose co-ordinates are x and y, drawn to the line whose equation is $y' = x' \tan. a + b$ is equal to $y \underset{1}{\cos}\, a - x \sin a - b \cos a$, and if we multiply this by $\sec. \theta = \frac{1}{\cos \theta_1}$ we shall have the length of the line which is drawn from the point whose co-ordinates are x and y, forming a given angle with the first of the parallel lines, its n^{th} power will therefore be

$$\left\{\frac{y \cos a - x \sin a}{\cos \theta_1}\right\} - b \frac{\cos a}{\cos \theta_1}\Big\}^n$$

and similarly the n^{th} power of the line drawn from the same point to the next line will be

$$\left\{\frac{y \cos a - x \sin a}{\cos \theta_2} - \frac{b}{1}\,\frac{\cos a}{\cos \theta_2}\right\}$$

and so on for the rest of the lines.

Now the sum of all these quantities is to be constant; and if we put y cos. $a - x$ sin. $a = v$, and if we devellope these expressions, and arrange their sum according to the powers of v, we shall have a series of the form

$$Av^n - Bv^{n-1} + Cv^{n-2} - \text{and} \pm Mv \mp N = P = \text{constant}$$

or

$$Av^n - Bv^{n-1} + Cv^{n-2} \text{ and } \mp N - P = o$$

Now this equation will evidently have several real roots, and if P is less than N all its roots will be real, we shall therefore have, supposing its roots to be r_1, r_2, and r_n,

$$v = y \text{ cos. } a - x \text{ sin. } a = r_1 \text{ or } = r_2 \text{ or } = r_n$$

hence

$$y = x \text{ tan. } a + \left(\frac{1}{\text{cos. } a} r_1\right) \text{ or } y = x \text{ tan. } a + \left(\frac{1}{\text{cos. } a} r_n\right)$$

that is to say, the locus of the point from which the lines are drawn is a straight line parallel to the given lines, and if the constant quantity P is less than N, there will always be n different lines, which will satisfy the conditions of the propositions.

Prop. 56. "Let there be any number p of straight lines given by position, and also let there be any number q of right lines given by position: and let all the lines be either parallel to each other, or all intersecting each other in one point: and let n be any number, and from a point let there be drawn right lines in given angles to all the right lines given by position; and let the sum of the n^{th} powers of the lines drawn in given angles to the first number of right lines given by position, be to the sum of the n^{th} powers of the right lines drawn in given angles to the second number of lines given in position in a given ratio; the point from which the lines are drawn will be in a right line given by position."

Case 1. Let all the lines be parallel to each other and their equations will be

$$y' = x' \text{ tan. } a + b_1 \quad y' = x' \text{ tan. } a + b_2. \quad \text{\&c. } y' = x' \text{ tan. } a + b_p$$

$$y' = x' \text{ tan. } a + \beta_1 \quad y' = x' \text{ tan. } a + \beta_2 \quad \text{\&c. } y' = x' \text{ tan. } a + \beta_q$$

and let x and y be the co-ordinates of the point from which

the lines are drawn in given angles, and let the given angles which these lines form with the perpendiculars to the first set of lines be

$$\underset{1}{\theta},\ \underset{2}{\theta},\ \&c.\ \underset{p}{\theta}.$$

and those which they form with the perpendiculars to the second set be $\underset{1}{\eta}, \underset{2}{\eta}, \ldots \underset{q}{\eta}$.

Now it will appear from the demonstration of the last proposition that the sum of the n^{th} powers of the first set of lines drawn in the given angles will be

$$\left\{\frac{y \cos. a - x \sin. a}{\cos. \underset{1}{\theta}} - \underset{1}{b}\frac{\cos. a}{\cos. \underset{1}{\theta}}\right\}^n + \&c.$$

$$+\left\{\frac{y \cos. a - x \sin. a}{\cos. \underset{p}{\theta}} - \underset{p}{b}\frac{\cos. a}{\cos. \underset{p}{\theta}}\right\}^n$$

and similarly the sum of the n^{th} powers of the lines drawn in the given angles to the other set of q given lines will be

$$\left\{\frac{y \cos. a - x \sin. a}{\cos. \underset{1}{\eta}} - \underset{1}{\beta}\frac{\cos. a}{\cos. \underset{1}{\eta}}\right\}^n + \&c.$$

$$+\left\{\frac{y \cos. a - x \sin. a}{\cos. \underset{q}{\eta}} - \underset{q}{\beta}\frac{\cos. a}{\cos. \underset{q}{\eta}}\right\}^n$$

These two sums must, by the proposition, have a given ratio to each other, let the ratio be that of 1 to k, then if each term is expanded into a series, the developement will assume the form, (putting z for y cos. $a - x$ sin. a.)

$$Az^n + Bz^{n-1} + Cz^{n-2} + \&c.\ Mz + N = o$$

and k may always be so assumed that this equation shall have one real root at least which will be of the form

$$z = y \cos. a - x \sin. a = r$$

consequently the locus of the point from which the lines are drawn is a line given by position, and parallel to the other lines. It is possible that n lines may exist, each of which may be the locus of the point, and these will all be parallel to the given lines.

Case 2d. When all the lines meet in a point, the equations to the lines will in this case be

$$y' = x' \tan. \underset{1}{a} + b \quad y' = x' \tan. \underset{2}{a} + b \quad \ldots \quad y' = x' \tan. \underset{p}{a} + b$$

$$y' = x' \tan. \underset{1}{\beta} + b \quad y' = x' \tan. \underset{2}{\beta} + b \qquad y' = x' \tan. \underset{q}{a} + b$$

and it will readily be found that the sum of the n^{th} powers of the lines drawn in the given angles to the first set will be

$$\left\{ y - b \frac{\cos. \underset{1}{a}}{\cos. \underset{1}{\theta}} - x \frac{\sin. \underset{1}{a}}{\cos. \underset{1}{\theta}} \right\}^n + \&c. + \left\{ y - b \frac{\cos. \underset{p}{a}}{\cos. \underset{p}{\theta}} - x \frac{\sin. \underset{p}{a}}{\cos. \underset{p}{\theta}} \right\}^n.$$

and the sum of the n^{th} powers of those drawn to the second set will be

$$\left\{ y - b \frac{\cos. a}{\cos. \theta} - x \frac{\sin. a}{\cos. \theta} \right\}^n + \&c. + \left\{ y - b \frac{\cos. \underset{q}{a}}{\cos. \underset{q}{\theta}} - x \frac{\sin. \underset{q}{a}}{\cos. \underset{q}{\theta}} \right\}^n$$

if the ratio of these two sums be that of one to k, and if each term be expanded, putting $y - b = z$, we shall have a series of the form

$$A\, z^n + B\, x\, z^{n-1} + \&c. + M\, x^{n-1}\, z + N\, x^n = 0$$

and this by properly assigning the value of k may always have at least one real root of the form

$$z = y - b = r\, x$$

consequently there is always one right line which is the locus of the point from which the lines are drawn, and it appears from the equation that this line passes through the same point: it is possible that there may be n different lines, each of which may be the locus of the point, and in this case they will all meet in the common point of section of the given lines.

I shall now offer a few remarkable properties of the circle which are the geometrical translation of some trigonometrical formulæ which occured in other enquiries.

THEOREM I.

In a circle (fig. 5) take any arc AV, bisect it in B, bisect BV in C and so on, and let there be n bisections, and let XV be the last arc: draw sines to the points B, C, &c. X, and make the angles $\mathrm{E\underset{1}{B}T}$, $\mathrm{F\underset{2}{C}T}$, &c. $\mathrm{G\underset{n}{X}T}$ respectively equal to

EBO, FCO, &c. GXO, and let the lines BT_1, CT_2, &c. XT_n cut the radius OV produced in T_1, T_2, &c. T_n; and from T_1 the first of the points, draw a tangent TP_1, to the circle, and from T_2, the last but one of these points, also draw a tangent T_2P_2 to the circle. Then is

$$T_1V \times T_2V \times T_3V \times \&c.\ T_nV = \left(\frac{T_1P_1}{T_2P_2}\right) OV^n$$

for the sake of brevity let the rad. $OV = 1$

Let the arc $AV = \theta$ then $BV = \frac{\theta}{2}$, $CV = \frac{\theta}{2^2}$, $XV = \frac{\theta}{2^n}$

and $OV_1 = 2\cos.\frac{\theta}{2}$ &c. $OT_n = 2\cos.\frac{\theta}{2^n}$

also $T_1V = 2\cos.\frac{\theta}{2} - 1$ $T_2V = 2\cos.\frac{\theta}{2^2} - 1$ $T_nV\ 2\cos.\frac{\theta}{2^n} - 1$

and we shall find $T_1P_1^2 = \left(2\cos.\frac{\theta}{2}\right)^2 - 1$

and $T_nP_n = \left(2\cos.\frac{\theta}{2^{n-1}}\right)^2 - 1$

consequently the theorem is as follows:

$$\left(2\cos.\frac{\theta}{2} - 1\right)\left(2\cos.\frac{\theta}{2^2} - 1\right)\ldots\left(2\cos.\frac{\theta}{2^n} - 1\right) =$$

$$= \frac{\left(2\cos.\frac{\theta}{2}\right)^2 - 1}{\left(2\cos.\frac{\theta}{2^{n-1}}\right)^2 - 1}$$

$$= \frac{3 - 4\left(\sin.\frac{\theta}{2}\right)^2}{3 - 4\left(\sin.\frac{\theta}{2^{n-1}}\right)^2} = \frac{3\sin.\frac{\theta}{2} - 4\left(\sin.\frac{\theta}{2}\right)^3}{\sin.\ 2}$$

$$\frac{\sin.\frac{\upsilon}{2^{n-1}}}{3\sin.\frac{\theta}{2^{n-n}} - 4\left(\sin.\frac{\theta}{2^{n-1}}\right)^3} = \frac{\sin.3\frac{}{2}}{\sin.\frac{\theta}{2}}\ \frac{\sin.\frac{}{2^{n-}}}{\sin.3\ _{n-1}}$$

* In this and the following Theorems I shall reduce the geometrical enunciation to some trigonometrical formulæ, and the

THEOREM II.

Take any arc AV, fig. 5, and take BV equal to one third of it, take CV equal to one third of BV and so on, and let there be n trisections, and let XV be the last arc: also bisect the fi t arc AV and the last arc XV in the points B and Y: and let the sine NL and QH be drawn, and having drawn the lines BT_1, BT_2, &c. BT_n, making with the perpendiculars BE, CF, and XG the same angles as do the lines OB, OC, &c. OX, we have

$$TV_1 \times TV_2 \times TV_3 \times \&c.\ TV_n = \frac{OL}{OH} OV^n$$

making $AV = \theta$ we have $BV = \frac{\theta}{3}$ &c. $XV = \frac{\theta}{3^n}$, $OL = \cos. \frac{\theta}{2}$ $OH = \cos. \frac{\frac{1}{2}\theta}{3^n}$ and $TV = 2 \cos. \frac{\theta}{3} - 1$ &c. $TV_n = 2 \cos. \frac{\theta}{3^n} - 1$

hence the theorem becomes

$$\left(2 \cos. \frac{\theta}{3} - 1\right) . \left(2 \cos. \frac{\theta}{3^2} - 1\right) \ldots\ldots \left(2 \cos. \frac{\theta}{3^n} - 1\right) = \frac{\cos. \frac{\theta}{2}}{\cos. \frac{\frac{1}{2}\theta}{3^n}}$$

THEOREM III.

In the same figure having trisected the arcs as above we

$$ST_1 \times ST_2 \times ST_3 \times \&c. \times ST_n = \frac{NL}{YH} OV^n$$

by employing the same substitution this expression will be converted into

$$\left(2 \cos. \frac{\theta}{3} + 1\right) . \left(2 \cos. \frac{\theta}{3^2} + 1\right) \ldots \left(2\cos \frac{\theta}{3^n} + 1\right) = \frac{\sin. \frac{1}{2}\theta}{\sin. \frac{1}{2}\frac{\theta}{3^n}}$$

THEOREM IV.

In the same figure having trisected the arcs, as above, draw from the points T_1, T_2, &c. T_n the tangents to the circle

demonstrations of these may be found in the Memoirs of the Analytical Society, pages 8 and 9.

$\underset{1\,1}{TP}$ &c. $\underset{n\,n}{TP}$, then

$$\underset{1\,1}{TP} \times \underset{2\,2}{TP} \times \underset{3\,3}{TP} \times \text{\&c.} \times \underset{n\,n}{TP} = OV^n \times \sqrt{\frac{AR}{XG}}$$

this may easily be deduced by multiplying the two expressions in Theor. II. and III. and extracting the square root.

THEOREM V.

With any radius OA describe a circle, (fig. 6.) and with the same centre and double that radius describe another circle; take any arc AB in the first circle and bisect it in C, bisect CB in D, and so on, and let there be n bisections, and let NB be the last arc; and through the extremity of each arc draw diameters to the circle, and also draw the sines AM, CG, &c. NL, and let CG be the sine of the second arc in the series, and EH be the sine of the last but one: make IG$=$GO and KH$=$HO, and from the points I and K draw the tangents IR, KS to the inner circle, and at the point B draw the tangent BT: then

$$\underset{1\,1}{PE} \times \underset{2\,2}{PE} \times \underset{3\,3}{PE} \times \text{\&c.} \times \underset{n\,n}{PE} = \left(\frac{IR}{KS}\right)^2 \times \frac{AM}{NL}(2OB)^n$$

making AB $= \theta$, we have CB $= \frac{\theta}{2}$ &c. NB $= \frac{\theta}{2^n}$

$$\underset{1\,1}{PE} = 2\,CO - \underset{1}{OE} = 2 - \sec.\frac{\theta}{2}, \text{ \&c. } \underset{n\,n}{PE} = 2\,CO - \underset{n}{OE} = 2 - \sec.\frac{\theta}{2^n}$$

$$IR^2 = \left(2\cos.\frac{\theta}{2}\right)^2 - 1 \quad KS^2 = \left(2\cos.\frac{\theta}{2^{n-1}}\right)2 - 1 \quad AM = \sin.\theta$$

$$NL = \sin.\frac{\theta}{2}$$

consequently the theorem becomes

$$\left(2 - \sec.\frac{\theta}{2}\right).\left(2 - \sec.\frac{\theta}{2^2}\right)\ldots\left(2 - \sec.\frac{\theta}{2^n}\right)$$

$$= \frac{\left(2\cos.\frac{\theta}{2}\right)^2 - 1}{\left(2\cos.\frac{\theta}{2^{n-1}}\right)^2 - 1} \cdot \frac{\sin.\theta}{\sin.\frac{\theta}{2^n}}\,2^n$$

$$= \left(2 - \frac{1}{\cos.\frac{\theta}{2}}\right).\left((2 - \frac{1}{\cos.\frac{\theta}{2^2}}\right)\ldots\left((2 - \frac{1}{\cos.\frac{\theta}{2^n}}\right)$$

$$= \frac{\left(2\cos.\frac{\theta}{2}-1\right).\left(2\cos.\frac{\theta}{2}-1\right)\,.\,.\,\left(2\cos.\frac{\theta}{2^n}-1\right)}{\cos.\frac{\theta}{2}\,.\,\cos.\frac{\theta}{2^2}\,.\,.\,.\,\cos.\frac{\theta}{2^n}}$$

and multiplying by $\cos.\frac{\theta}{2}\cos.\frac{\theta}{2^2}\,.\,.\,.\,\cos.\frac{\theta}{2^n} = \frac{\sin.\frac{\theta}{2^n}}{2^n\sin.\ \theta}$ we have

$$\left(2\cos.\frac{\theta}{2}-1\right).\left(2\cos.\frac{\theta}{2^2}-1\right)\,.\,.\,.\left(2\cos.\frac{\theta}{2^n}-1\right)$$

$$\left.2\cos.\frac{\theta}{2}\right)^2-1$$

$$\left(2\cos.\frac{\theta}{2^{n-1}}\right)-1$$

which is the same as the expression in Theorem I.

THEOREM VI.

Describe a circle (fig. 6) with any radius OA, and with the same centre and double that radius describe another circle; take any arc AB in the first circle, and let BC be one-third of it; let BD be one-third of BC and so on, and let BN be the last arc. At the point B draw the tangent BT, and through the extremity of each arc draw diameters to the circles cutting the tangent BT in the points E^1, E^2, &c. $\underset{n}{E}$; then the continued product of $\underset{1\,1}{QE}\times\underset{2\,2}{QE}\times$ &c. $\times\underset{n\,n}{QE}$ is to the continued product of $\underset{1\,1}{PE}\times\underset{2\,2}{PE}\times$ &c. $\times\underset{n\,n}{PE}$ in the ratio of the tangent of half the first arc AB, to the tangent of half the last arc BN. Making AB $=\theta$ we have

$$\underset{1\,1}{QE} = 2+\sec.\frac{\theta}{3}\ \text{\&c.}\ \underset{n\,n}{QE} = 2+\sec.\frac{\theta}{3^n}$$

$\underset{1\,1}{PE}=2-\sec.\frac{\theta}{3}$. &c. $\underset{n\,n}{PE}=2-\sec.\frac{\theta}{3^n}$ and the theorems becomes

$$\frac{\left(2+\sec.\frac{\theta}{3}\right).\left(2+\sec.\frac{\theta}{3^2}\right)\,.\,.\,.\,.\left(2+\sec.\frac{\theta}{3^n}\right)}{\left(2-\sec.\frac{\theta}{3}\right).\left(2-\sec.\frac{\theta}{3^2}\right)\,.\,.\,.\,.\left(2-\sec.\frac{\theta}{3^n}\right)} = \frac{\tan.\frac{1}{2}\theta}{\tan.\frac{1}{2}\frac{\theta}{3^n}}$$

$$\frac{(2\cos.\frac{\theta}{3}+1)\,.\,(2\cos.\frac{\theta}{3^2}+1)\ldots(2\cos.\frac{\theta}{3^n}+1)}{(2\cos.\frac{\theta}{3}-1)\,.\,(2\cos.\frac{\theta}{3^2}-1)\ldots(2\cos.\frac{\theta}{3^n}-1)}$$

$$\frac{\tan.\ \frac{1}{2}}{\tan.\ \frac{1}{2}\frac{\theta}{3^n}}$$

which is nothing more than the expression in Theorem III· divided by that in Theorem II.

Art. III. *On some Phenomena attending the Process of Solution, and on their Application to the Laws of Crystallization.* *By* J. Frederic Daniell, *Esq. F.R.S. & M.R.I.*

It has long been known that mechanical action is in many cases opposed to chemical affinity, and that the efficacy of the latter is not unfrequently resisted by the energy of the former. The attraction of cohesion is often required to be diminished, before new arrangements can be formed. Elasticity must be counteracted, and gravity modified. Instances of the agency of the two former powers in controlling the re-action of bodies, are too common to require illustration, and of the latter I shall only mention one as more particularly connected with the present subject.

If a mass of any moderately soluble salt be suspended in a vessel of water, we may shortly observe that it is not equally acted upon by the fluid. We shall perceive that it has been more dissolved toward the upper, than the lower part, and the whole piece will assume, more or less, the form of a cone, with the apex at the surface of the liquid. The particles of water which are in immediate contact with the salt combine with a portion of it, and thus becoming specifically heavier than the remainder, sink to the bottom of the vessel; others succeed, and follow the same course. A layer of saturated

solution is thus deposited, which increases in bulk as the process proceeds, protecting in its rise that part of the mass which is covered with it, from further action.

The power of the solvent is therefore longer exercised upon the upper than the lower surfaces, producing, by its gradual decrease, the above mentioned peculiarity of shape.

This modification of solution by gravity is entirely counteracted by agitation, but if the process be carried on in a glass vessel, with some care, the current of descending liquid may be rendered perceptible to the eye.

But there is a much more important circumstance attending this process, which it is the particular object of the present paper to illustrate and consider. Independent of the modification of form produced by the cause above described, the surface of a body is never equally acted, upon by a solvent. Striæ or ridges may be detected in various places, and, indeed, generally cover the whole of its superficies, which prove, not only that the mechanical attraction of the solid has resisted chemical action, but that it has resisted it more in some directions than in others. The following experiments, which only require time and moderate attention, while they give determinate results, are explanatory, at once, of the cause and progress of the phenomena.

If we immerse an amorphous mass of alum in water, and set it by in a place where it may remain undisturbed for a period of three or four weeks, at the expiration of that time, we shall find that it has assumed the pyramidal form before described. Upon a further examination, we shall observe that the lower end of the mass presents the form of octohedrons and sections of octohedrons, as it were, carved or stamped upon its surface. These figures will be high in relief, and of various dimensions.—They will be most distinct at the lower extremity, becoming less so as they ascend, till at length they are totally obliterated.

A continuation of the process, however, would evidently resolve the whole into similar figures, their cessation arising solely from that superior power of solution which subsists in the upper stratum of the liquid.

These crystalline forms are produced when the water is partially saturated with the salt, and acting with diminished energy, is nearly counterbalanced by its mechanical structure; and we are thus put in possession of the important fact, that this latter power does not merely act, as has been hitherto supposed, in the grosser forms of aggregation, but in the more complicated and delicate arrangements of crystalline polarity.

This regular structure is developed both when we employ an amorphous mass and a regular crystal, proving that the ultimate arrangement of particles is the same in both; and that the like disposition exists, both when the slowness of approximation has bounded the solid with symmetric planes, and when the suddenness of the condensation has forced the aggregated molecules into a more contracted space.

This new process of dissection admits of more extensive application than might at first be imagined, and we are thus furnished with a method of analysing crystalline arrangements, which promises to lead to important results. The geometrical figures produced by these means, are not less determinate when the process has been carefully conducted, than those which result from the common methods of crystallization, and they are the more instructive, inasmuch as we are presented in the same group with an extensive series of modifications, and decrements of the primitive form, which shew by their relative position, and mutual connection, the gradual steps by which one form passes into another.

Borax submitted to the same cautious solution, produced crystalline forms not less distinct than alum. Sections of eight-sided prisms with various terminations were embossed upon the mass, which in some directions were subdivided, by lines parallel to the terminal faces into rhomboidal figures.

This salt requires a much longer time for the operation than the former, the result never being distinct till after six weeks from the first immersion.

It is not easy to select pieces of salts proper for this experiment. The larger the fragments or crystals are, and the more free from flaws or air-bubbles, the more perfect will be the

series produced. It is hardly necessary to mention, that a certain proportion must be kept up between the size of the mass and the volume of water. If the latter should exceed, too much of the former would be dissolved before the proper equilibrium was produced between the mechanical and chemical powers. This proportion must also bear a certain ratio to the solubility of the body to be acted upon; a more soluble salt, obviously taking a less quantity of water to produce a given effect than one which is less so.

Crystals of sulphate of copper are much more soluble than those of alum or borax, but with proper care were not less beautifully displayed. It was found more effectual to place them in a solution prepared before hand, and not quite saturated. This expedient was also adopted with some other salts which require a degree of management on account of their great solubility. The rhomboids of this substance were thus longitudinally divided into prisms, terminated with rhombic faces.

Sulphate of magnesia and nitrate of potash were equally distinct in the result of the experiment. The former presented sections of four-sided prisms, and low four-sided pyramids, the meeting of whose planes would produce a flattened octohedron; and the latter, six-sided prisms and six-sided pyramids, forming by their intersection the triangular dodecahedron.

Fused lumps of those salts which melt by the application of heat, were likewise submitted to the experiment, but the result was unsatisfactory. Phosphate of soda, nitrate of ammonia, and nitrate of potash, when treated in this way, were reduced to a soft paste, owing probably to some slight degree of decomposition, or to the avidity with which they reattracted that portion of water which they had lost by exposure to a high temperature.

It being thus evident that that power, which disposes bodies to arrange themselves in a certain symmetrical order, is an efficient force which not only attracts their ultimate particles together when removed from one another, but tends to preserve them in that order against the attacks of any opposing power; and it being likewise evident that such arrangement

takes place, not only in the finer forms of what are commonly called crystals, but also in bodies which bear no external marks of regularity, the idea suggested itself of trying whether the effect of more complicated chemical action might not present analogous results, in bodies which are not acted upon by water.

A crystal of carbonate of lime was first immersed in dilute muriatic acid. It evidently was not equally attacked by the solvent, but the action of this acid, however much weakened, was too violent to enable any mechanical arrangement of the salt to oppose an adequate resistance to it. Another crystal was treated in the same manner with vinegar. The decomposition was much more slow, and at the end of a few days the surface of the spar was found to be marked with lines, which by their mutual intersection, presented the primitive rhomboidal form of carbonate of lime; besides these deeper divisions, finer and more numerous strokes crossed the planes of the solids, in the direction of the greater angles.

The result of this experiment was perfectly satisfactory, although the crystals were not so prominent as in the instance of those salts which were acted upon by water. This difference is owing to the peculiar circumstances of the solution. The disintegration of a salt in water is quiet, and undisturbed by the extrication of any foreign body which might retard its progress. But in the action of an acid upon carbonate of lime, the latter is not only dissolved, but decomposed. The gas which is extricated, interferes very essentially with the effect. The manner in which it interposes will perhaps be better understood from the following experiment:

If we immerse a crystal of carbonate of lime in muriatic acid, we shall find that the air-bubbles do not rise immediately from the point of extrication, through the liquid, but follow one another up the sides of the solid in continual succession; its attraction drawing them from the perpendicular direction. Those portions therefore, over which the streams of gas pass, are protected from the action of the acid, and the spar will, after some time, be found to be indented with deep striæ in the line of their course. This effect of the nascent gas must

evidently interfere with the result of experiments which depend upon so nice a balance of circumstances, as those which we are considering.

Carbonate of barytes and carbonate of strontian, treated in the same way with vinegar, were dissolved into hexahedral prisms, but the effect was here also limited by the action of the gas.

A lump of bismuth, which had been fused without any particular precaution in a crucible, was next subjected to the action of diluted nitric acid. At the end of a few days its surface was covered with small cubic figures, which presented the same curious linear arrangement which is observable in the artificial crystallizations of that metal.

Antimony was also dissolved in the same way: and the parts which most resisted the power of the acid, presented a series of rhomboidal plates.

Nickel, submitted to the action of strong nitric acid, was covered at the expiration of a fortnight with perfectly-defined regular tetrahedrons. The length of the axis of these crystals was about $\frac{1}{20}$ of an inch, and there was no regularity observable in their relative position upon the mass.

Some other metals did not present satisfactory results: and indeed in all, the circumstances which affect their solution are still more complicated than those which interfere in the decomposition of the carbonates. The process of oxidation is combined with an analogous extrication of a gaseous body.

Sulphuret of lead when acted upon by nitric acid, was evidently indented with lines which crossed one another at right angles, thus giving traces of cubic arrangement. But the success of the experiment was still further impeded by the sulphur, which choaked the divisions of the crystals almost as soon as formed.

A crystal of quartz was immersed in diluted fluoric acid. The sides of the prism were embossed with rectilineal figures, the boundary lines of which were mostly parallel to the base or sides of the triangular pyramid, or to the sides of the prism. The planes of the summit were marked with lines which

crossed one another at alternate angles of about 94° and 86°, forming the primitive obtuse rhomboid of that mineral.

A polished cornelian of a beautiful red colour, with a very slight cloud in the centre, was subjected to the action of the same acid. In a short time it presented the same kind of concentric arrangement which is so well known as existing in agates, although nothing of that structure was before visible. In one part where it had been more acted upon than in others, a small nucleus of quartz of a tetrahedral form, projected parallel to the sides of which the coats of the stone were arranged with the utmost regularity, presenting a series of concentric triangles. The angles of the tetrahedron corresponded as nearly as could be ascertained with those of the integrant molecule, ascribed by M. Haüy to quartz.

Let us now enquire whether this new method of analysis may not be calculated to throw some light upon crystalline arrangements in general. The mechanical division of a crystal by mechanical force, was the first experiment which gave any idea of the laws by which nature is governed in the formation of mathematical figures. But this is a clumsy contrivance, compared with the delicate dissection thus displayed to us. Nature herself is here the operator, and she is thus made to unfold before our eyes, the intricate and finer traces of her work.

I shall commence the observations which I have to make, with the forms produced by the solution of alum.

The first thing which would naturally strike us, in an examination of a mass which had been thus analysed, would be, that the crystals do not all present the same form. Secondly, that the nature of the forms produced, varies with particular faces of the original mass.

Allowing the light to fall in one direction, we shall perceive it reflected from the faces of octohedrons and sections of octohedrons, all upon the same plane; some of these would have their summits truncated, and others perfect; some again would furnish the equilateral triangle of the octohedral face, while others would be continued in the same plane, furnishing another triangle joined to the base of the former. In short,

every modification of figure arising from the intersection of lines at angles of 60 and 120 degrees, would be presented on this face.

If we now gently incline the mass, the reflection will arise from a set of forms differing very materially in their angles, from those already described.

Right angled parallelograms of every dimensions, sometimes affecting the form of a square, and often extended in either direction almost to an evanescent line, will be most common. These, however, will be modified in many places by intersections of 60 and 40 degrees, and rhomboids will hence result of corresponding angles.

The relative position of these forms is the next thing remarkable. Suppose the piece of alum originally selected for the experiment, to be of a lengthened form, and that its length is in the direction of the axes of the octohedrons of which we may suppose it composed. After the operation, if we hold it in a horizontal position before the light, with one end towards us, the reflection will arise from the right angled parallelograms and the figures of the same class (fig. 2). Holding it still in this direction, let us turn it upon its axis 45 degrees. At this interval we shall again find the light reflected from similar figures, and twice more at the same relative distance, till we arrive again at the face from whence we set out. Similar faces may also be detected upon the two summits, arising from what would commonly be called truncations of the angles. If the solution had taken place alone upon the faces above pointed out, till the resulting planes had intersected each other, it is obvious that various right angled parallelopipedons would have been the result, and that the cube might have been one amongst many other possible modifications.

Instead of holding the mass horizontally, let us incline it towards us at an angle of 60 degrees. The octohedral faces before described, will now come in view (fig. 1) Upon turning it again from right to left, as before, a similar repetition of these faces also will be perceived at intervals, corresponding to the right angled crystals (that is to say) at every

quadrant of the turn. Upon reversing the mass, corresponding sections will be visible on the other end, and diametrically opposed to the former on every side. If we imagine these planes continued to the point of mutual intersection, regular octohedrons will be formed. But a combination of both these circumstances may arise. A prism may be produced by the solution of the salt upon four sides, and octohedral terminations may be formed by solution in the last direction, in place of the plane summits of the cube. Thus the regular four-sided prism, terminated by regular four-sided pyramids, may be arranged.

But a further examination before the light, as described, will present us with other faces intermediate between all the series of those already pointed out; that is to say, between the four ranges of parallelograms and the four ranges of octohedral faces. If the reduction of the salt be carried on in their direction, as well as in that of the original succession, eight-sided prisms would be developed, which would be either terminated by four or eight-sided pyramids, according as the structure of the summits should follow the simpler or more complex law.

These forms are not the mere creatures of supposition, but actually are produced by the spontaneous dissection described. They are not of course entirely isolated, but they are, generally speaking, much more distinct than those which occur in the mineral kingdom, and upon which mineralogists found their calculations.

If it should be supposed, that these crystals might possibly be the result of reformation in consequence of evaporation, and not dissolved out as here asserted, it may be remarked:

First. That in the instances where regular crystals have been treated in this manner, the sections formed are all referable to one common centre of attraction. The axes of the several figures are all in one direction, and their corresponding faces parallel to the same plane. Secondly. That with reference to the metals, carbonate of lime, &c. the supposition is obviously impossible.

But the following results of actual experiment are best adapted to remove any such impression.

A mass of alum, weighing 1448 grains, was immersed in 15 oz. of water, and set by in a quiet place. After the lapse of 16 hours it was taken out, carefully dried with blotting paper, and weighed. It had lost 323 grains. Its faces were very slightly marked with regular intersections. It was now replaced in its former position with great accuracy, and, after seven hours immersion, was again dried, weighed, and examined. It had experienced a further loss of 218 grains. The rectilineal intersections were much in the same state. After seven hours more immersion, it lost 92 grains, and the crystals were bold and very distinct. In eleven hours more, had lost 18 grains, and in twenty-four hours further, 54 grains.

The forms, during all this period, were increasing in relief, and at the expiration of it, were in full perfection.

Another experiment is no less decisive of the fact, and is further interesting, as presenting a remarkable modification of the action which we are now discussing.

A large six-sided prism of nitre was partly immersed in a proportionate quantity of water. The crystal presented a very common modification of the salt, two opposite sides being of much larger dimensions than the other four. The lower end was dissolved into hexahedral pyramids, as before described. But the chief action of the solvent was exerted in reducing the prism throughout the whole length immersed, from the figure before described, to one with exactly equal faces. This part was thus admirably contrasted with that which had not been exposed to the action of the fluid, and furnished a result the most instructive that could be imagined.

Now it is evident, that no general theory of crystallization can be applied to the cases under contemplation, which is not founded upon such a disposition of constituent particles, as may furnish all the modifications of form above described, by the mere abstraction of certain individuals from a congeries, without altering the original relative position of those which remain. That is to say, supposing we adopt the hypothesis of the spherical form of the molecules, it will not be sufficient

that a cube may be constructed by the superposition of four balls upon the top of four other balls,* and an octohedron by placing four spheres in a square, with two others in the interstices between them, (in which two combinations it is evident that the position of no three particles is alike) but the disposition of the cube must include that of the octohedron, and this latter must be obtainable by the equal abstraction of certain members of the former, without interfering with the quiescent state of the remainder.

Similar spheres, endued with an equal power of attraction, must always, when in contact, retain one relative position. We have, moreover, the means of ascertaining, from experiment, what that position is. The power of gravity is coincident, in one direction, with the power of attraction.

If, therefore, we ascertain what distribution takes place amongst a number of balls freely given up to the direction of the former power; we also know the order of combination arising from the force of attraction in every direction.

If we imagine sixteen similar spheres arranged side by side, upon the same plane, in the form of a square, nine others, placed in a parallel plane upon them, will roll into the interstices between them. In this direction the power of gravity is coincident with the power of individual attraction, and, supposing the latter force to have existed, an equilibrium of power would have been established by the same arrangement.

If sixteen more balls were thrown upon these, four only would be added to the pile by gravity, but by the power of attraction the whole would place themselves with their centres immediately over the centres of the first layer, the intermediate stratum acting both upon the upper and lower series with the same energy.

Such being the relative position which spherical particles, endued with an equal power of attraction, are disposed to assume, how far would a congeries of this nature furnish the

* See the construction of the cube as proposed by W. H. Wollaston, M. D. Sec. R. S. Phil. Trans. 1812.

different forms connected together in the dissected alum? Fig. III. is a perspective representation of such a group.

And first the rectangular parallelopipedon is produced, as seen in the figure. This may obviously be extended on any of its sides, so as to acquire any relative proportion of adjoining planes.

The faces of these figures, we find in the analysis of alum, are liable to be modified by lines intersecting them at certain determinable angles. If in Fig. III. we imagine the upper row of spheres *a* 6. to 11 removed, a new face will be formed, the terminal line of which a^5. c^6. will cut the line *c. c. c.* at an angle of 60 degrees. So likewise if the three rows a^5. a^6. b^5. be abstracted, the line a^4. c^6. will form, with the same, an angle of 40 degrees, and these angles exactly coincide with those measured upon the corresponding faces of the salt.

Another modification of the rectangular parallelopipedon is afforded by the formation of four new faces, instead of the four edges of the solid.

Thus if from Fig. III. we abstract the particles a^6. c^6. e^6. g^6. a new plane is generated, and a similar reduction being made on the other three edges an eight-sided prism is constructed. Fig. IV. represents this form as taken out of the original mass, Fig. III.

It is worthy of remark, that this crystal can only be deduced from the combination in one direction, viz. *a. g.* for if we remove the row of spheres *a. a. a.* a new face, indeed, will be produced, but forming, with the original plane, a very different angle from that of the octohedral prism. But this position of the figure corresponds exactly with its situation in the dissected mass.

We thus perceive, that all the crystals upon the face of the alum, which we have been contemplating, may be satisfactorily derived from a series of spheres maintaining that relative position which they must assume if endued with the power of mutual attraction; and we have likewise seen, that there are certain peculiarities of situation regarding the planes of these figures and the figures themselves, which exist both in the natural and artificial combination. The next set of forms are

to be found upon planes cutting the former at angles of 60 degrees.

These consist chiefly of equilateral triangles, or trapeziums arising from the excision of one of their angles. They spring from the four similar planes of the parallelopipedon, and their summits are in the direction of the axis of the eight-sided prism. They are placed indifferently at the two ends of the mass, and the mutual intersection of their planes forms the regular octohedron.

In Figure III. the removal of the balls a^1. to 11 would form two such planes; and the first glance of the eye is sufficient to shew, that they are divisible into equilateral triangles. Similar planes are formed by the abstraction on the other end, of the balls g^1. to 11, and Fig. V. presents the octohedron of eight triangles, springing from the four sides of the rectangular solid.

But these triangular faces are not only joined, base to base, upon different planes, but likewise meet one another upon the same plane forming a rhomb, as in Fig. V. c^{17}. c^{18}. d^3. d^4. The conjunction of six such faces forms the regular rhombic parallelopiped, Fig. VI. whose situation may easily be traced in the rectangular solid, Fig. III. or the octohedron, Fig. V.

But the reduction of the mass, Fig. III. may be supposed to take place at the same time in both directions; that is to say, parallel to the original rectangular planes, and to the faces which intersect them. Thus, the four-sided prism with the pyramidal summit, Fig. VII. may easily be extracted from the original congeries.

But it is necessary to demonstrate the disposition of the cube in this arrangement, before we can apply it generally to the solution of the octohedral structure. The rectangular parallelopipedons which have been already described are situated with their sides parallel to the edges of the octohedron derived from the same construction.

But the mechanical division of a cube of fluor spar presents us with an octohedron whose edges are parallel to the diagonals of its circumscribing cube. Fig. VIII. 1. 2. 3. 4. 5. 6.

represents the octohedron as derived from the original congeries. Eight more balls placed upon the triangular faces of this solid, present us with the desired combination. Six only of these can be seen in the figure, *a b. c. d. e. f.* and these will likewise be found to be comprehended in the first arrangement. Both forms may again be satisfactorily traced in the eight-sided prism, Fig. IV. distinguished by the same letters and figures.

The six-sided prism still requires demonstration to complete the series of homogeneous disposition.

If the planes, which furnish the faces of the octohedron, be continued in a lateral direction, instead of terminating in a point, in conjunction with two of the faces of the original figure, the hexahedral prism, Fig. X. will result, whose base is marked in Fig III. by the letters b^4. b^5. c^4, c^5. c^6. d^4 d^5. But this solid is symmetric, not regular, its angles not being all equal, those which are opposed only corresponding with each other. The measure of two of the angles of this figure is 109°. 28′, and of the remaining four 125°. 16′.

We must seek in another direction for the regular six-sided prism, whose angles are all 120°.

One sphere surrounded by six others upon the same plane forms a regular hexagon. Now the particles in the arrangement we are considering, can only be thus situated upon a plane which is parallel to the face of an octohedron. Fig. X. A, presents us with the solid required, extracted in this direction. It is admirably adapted to shew the connection between three simple crystals. The two hexagonal faces *a. b. c. d. e. f. g.* are connected together by an intermediate octohedron, 1. 2. 3. 5. 6. to the opposite faces, of which they are both mutually parallel. The outline of the prism is filled in by substituting the regular cube for the octohedron, that is to say, by placing eight balls upon the eight triangular faces of the latter.

The position of the prism, as thus developed, agrees exactly with the results of the dissected alum. For although this figure never has been extracted from the mass, yet regular hexagons often are sculptured upon the octohedral

faces, but never upon those which are parallel to the sides of the rectangular solids.

Thus, then, is the problem proposed resolved, and the surfaces and lines of the solids produced, are in no instance interrupted, or broken, by a space equal to the diameter of one particle.

Will any other geometrical solid furnish as simple and satisfactory a solution?

Let us assume the cube as the integrant particle, and, in so doing, we shall have the advantage of considering the possibility of an octohedral structure: for, according to M. Haüy's ideas, the former will include the latter, as the cube is the subtractive particle of the octohedron, that is to say, it is the parallelopipedon produced by adding the vacuity, which is left between each octohedron, in the arrangement, to its corresponding particle.

Now an arrangement of cubes in equilibrio must take place by the application of the particles, side by side. Fig. IX. represents the horizontal section of such a combination.

All the strata superimposed upon this must have the centre of each cube immediately over the one which is subjoined. The same figure will therefore furnish a perpendicular section of the congeries. A compound cube would be easily produced from this arrangement, by making the series of laminæ, imposed upon the base, equal in number to the individuals of that base. Four-sided prisms might also be constructed, of which 19. 21. 33. 31. may represent the base, and 34. 10. 12. 36. one of the sides. But a pyramidal termination to such a structure would only be formed by placing the cube 5. upon the cube 11. But then the angle 12. 5. 10. is an angle of 90 degrees, instead of 60, the octohedral summit furnished by the dissection of alum. For the same reason it is obvious that the octohedron cannot result from the solution of such a combination, in a direction parallel to the sides of the cubic particles.

It is easily demonstrable, that the mechanical resistance of this structure to any divellent power, is less in this direction than in any other, and consequently that it is not soluble

parallel to the diagonals of the particles. Thus in the lamina Fig. XII. the cube *p.* is in contact only with one other *n.* while *o* is attracted both by *n.* and *k.* So likewise half the force would be sufficient to remove *m. n. o.* in the lateral direction, to what would be required for the same purpose by *o. l. g.* in the diagonal direction. But let us, for a moment, suppose this difficulty overcome. The solution then takes place in a direction parallel to the diagonals of the particles. In this case the four-sided figure 4. 14. 28. 18. Fig. IX. will be the result, and the sides will be formed of the projecting edges of the cubes. A second lamina would be superimposed upon this, so that the centres and points of its particles might correspond with the centres and points 10. 15. 22. 17. and the last layer would consist of a single cube placed immediately over 16. In this manner a pyramid will be formed, of which the salient angles of the constituent cubes, will form the sides, and an angle measured upon their inclination will give 60 degrees; and if the like process be continued on the other side of the base, the regular octohedron, Fig. XI. will be formed.

And here it may be objected, that all angles are mathematical points, that mathematical points can have no dimensions, and, therefore, that no combination of them can be supposed to constitute a plane. But let us wave the strictness of the definition, and let us concede certain dimensions to such points. We will suppose that a row of these points might constitute a line, and that a series of such lines might form a plane. Whatever size, however, we grant to the angle of a cube, it is clear that its measure can bear but a very small proportion indeed to the lines and planes of which it is a part, and which constitute the sides of the solid. If the solution of the mass, which we are contemplating, take place at all in the diagonal direction, we must allow, that it may be carried on in the same till it arrives at the simplest number of particles, capable of forming the combination. This will consist of six cubes placed as in Fig. XIII.

This then is an octohedron of which the projecting angles of the three cubes 1. 5. 4. form one side, that is to say, the

three points *a. c. b.* form an appreciable quantity, while the planes, of which they are parts, are unappreciable: which is absurd.

But if this difficulty be valid with respect to a decrement by one range of particlès, how much greater must it not be, when we are forced to have recourse to the abstraction of two or more ranges in the arrangement of the crystal.

If we are thus led, by the gradual unravelling of the processes of nature, to trace the rules of architecture by which she constructs her rectilineal forms, the confirmation of our opinions may be drawn from those fortuitous instances, where she has left her work in progress, and as it were unfinished; the very imperfection of a crystal may thus lead to a knowledge of the relative arrangement of its ultimate particles, and those various faces which so often occur in the mineral kingdom, to modify and, as it were, perplex the primitive form, are by their position so many indices of the internal construction.

The following observation will thus furnish collateral proof of the inferences which we have drawn from the dissection of an octohedral arrangement. Nitrate of lead crystallizes in the same form as alum. If a strong solution of this salt be made, and a thread suspended therein, the crystals which attach themselves to it will be more or less perfect octohedrons. They will continue to increase in size for some days, but the process at last will cease. If the remaining liquid be now poured into a shallow vessel and set by in a quiet place, after a few weeks exposure to spontaneous evaporation, the bottom of the vessel will be found lined with crystals, which will appear to be no longer confined to the octohedral form. Octohedrons, tetrahedrons, cubes, four and six-sided prisms, with rhomboids, may be detected in every state of progression; but no one amongst them differing in the angles either of its finished or unfinished planes, from those which we have traced as naturally arising from the spherical construction. This, then, nearly amounts, at least in the method of obtaining the results, to an *experimentum crucis.*

Let us now consider some further peculiarities of the octo-

hedral structure.—Why should a congeries of particles, which is resolvable by chemical action into such a diversity of forms, be only divisible by chemical force in lines whose mutual intersection affords angles of 60 and 120 degrees? To resolve this question properly, we must consider the difference between the two powers employed.

And first, mechanical force can only have a partial and local action upon the surface of the body to which it is applied; but this action is continued through its substance in the direction in which the least resistance is offered to its efficacy. Its first effect is to separate the particles to which it is applied. The motion thus communicated to the first member of a series, is transmitted to the next with which it is in contact, and if it is combined with two, that one which is held in its situation by the least force, will be the first to obey the impulse. Thus in Fig. III. let us imagine a wedge applied between the two rows of particles, a^4. 35. and a^5. 36. It will first separate the two, and a^5. will recede from a^4. The motion which this row receives will be communicated to either b^4. or b^5. with which it is in contact. But b^4. is retained in its state of *inertia* by the power of three others a^4. b^3. c^4. while b^5. is only influenced by the attraction of two others b^4. c^5. As we increase the numbers of the series, so, it is obvious, we increase the tendency to separate in this direction rather than in the other.

Chemical attraction, on the contrary, is a general power as applied to the surface, but its abstraction of particles from the system does not communicate any motion to the internal arrangement. For instance, let us suppose the same mass exposed to the action of a chemical solvent. The four rows of particles a^1. a^6. g^1. g^6. would no doubt be the first to yield, because they are each attracted only by the power of two others; but afterwards, it is indifferent whether the action be continued by abstracting the series c^6. 11. thereby producing a face parallel to the original one, or the series a^5. 36. forming a plane cutting the former at an angle of 60 degrees. The process may thus easily be supposed to proceed differently in different parts of the same mass, and the lines

and planes, hence resulting, will form a much more extended series of modifications than can possibly arise from the one section which is alone produceable from mechanical division.

But there are many substances in nature resolvable, both by mechanical division and chemical solution, into regular solids, which, it is evident, cannot in any way be constructed of spherical particles. The rhomboids, for instance, of carbonate of lime, and the flattened octohedron produced by the action of water upon a four-sided prism of sulphate of magnesia. Is the theory calculated only to resolve the peculiarities of the former class; or may it be extended by similar observations so as to include crystalline arrangements of every description?

The latter of the two substances just instanced, would seem at once to point to a flattening of the elementary sphere, as affording a solution of the problem, with respect to its individual properties; but how far may this idea be generalized? And are there any peculiarities in this class of bodies, which may direct us to this explanation of their nature?

Before we proceed with this enquiry, there is one more quality of the spherical arrangement which it is necessary to point out, as in it consists the great simplicity of the combination, and its absence forms one of the most striking features of the modification which we are about to contemplate.

In Fig. III. the attraction which combines the spherical particles may be considered in two points of view,—First, we may remark, that the whole figure may be resolved into octohedral systems, or portions of octohedral systems, in which every six balls are united in the simplest manner in which it is possible for them to combine, as c^5. c^6. c^7. b^5. d^5. or

Secondly, We may divide them into tetrahedral groupes, and parts of the same, in which every four balls are equally balanced in the simplest position, as a^5. a^{16}. b^4. b^5. The same observation is applicable to all the forms of the same class. Thus in the rhomboid, Fig. VI. a^2. a^3. b^3. b^4. present the tetrahedron, and b^2. b^3. b^4. a^2. c^4. the octohedron.

Now let Fig. XIV. represent a flattened octohedron, composed of spheroids whose shortest diameters constitute their axes. The three particles *a*. b^2. b^4. will not form the basis of a tetrahedral group, as in Fig. V. and a fourth, imposed upon them, will not form with them any regular geometrical figure.—The reason is obvious. In both instances the sides and angles of the resulting solid are measured by the radii of the constituent particle. The radii of a sphere are all equal, therefore, it matters not what face is presented in the arrangement. In whatever manner you place a globe in contact with another of the same dimensions, their centres must be one diameter apart. Thus, in Fig. VI. the ball a^2. is in contact with four others b^2. b^3. b^4. b^5. from all of which its centre is removed one diameter; and so it is with respect to the ball a^3. which, although in a very different position with respect to the balls a^2. b^3. b^4. being in contact with them, is likewise equidistant one diameter.

Not so the arrangement of spheroids, Fig. XIV.; *a*. it is true, is equidistant from b^1. b^2. b^3. b^4. but neither the greater nor lesser diameter is a measure of that distance, but a radius intermediate between both. If we imagine another particle placed by the side of *a*. and likewise in contact with b^2. b^4. then will its centre be distant from that of *a*, the longest diameter, and from those of b^2. b^4. two of the intermediate radii: so again, if we place a seventh sphere upon the triangular face of a spherical octohedron, and an eighth upon the face immediately opposed to it, a regular rhombic parallelopiped is the result, whose sides and opposite angles are all equal. But if we place a spheroid upon the face *a*. b^2. b^4. of Fig. XIV. with an eighth c^4. opposed, a rhomboid indeed will be formed, but the face completed upon *a*. b^2. b^4. will have very different measures from the face *a*. b^1. b^3. c^4. Hence it appears, that the primitive figure of carbonate of lime, whose opposite faces are all equal, cannot result from *this* principle of attraction between spheroidical particles: for, though a given proportion between the axes might give some of the faces rhombs of the same measure as those required, yet the others, by differing from them, destroy the regularity necessary to the completion of the figure.

But as the regular acute rhomboid arising from the spherical congeries, may, as we have seen, be considered as the effect either of quadruple or sextuple attraction, and as the two powers, which are one with respect to it, are distinct in the case under consideration, having found the former insufficient to resolve the problem respecting carbonate of lime, let us endeavour to employ the data of the latter for the attainment of that purpose.

Fig. XV. represents a tetrahedral combination of flattened spheres. If we suppose the three c^1. c^4. c^6. and the three d^1. d^2. *e*. removed, a rhombic solid will be formed whose opposite sides and angles will be all equal: for *a* is equally removed from b^2. b^1. as also is c^2. But the side b^1. c^2. of the rhomb *a*. b^2. b^1. c^2. is also the side of the rhomb b^1. c^2. c^3. and the particle whose axis is in the same right line with that of *a*. the latter therefore is equal to the former.

This disposition of particles then fulfils the necessary conditions in the formation of the required figure. But any substance whose construction we may trace in its primitive form, must of necessity, by a parity of reasoning, exhibit the same in all the modifications of its shape. We will presently endeavour to establish this arrangement of carbonate of lime, from some of the secondary faces presented by that substance. Let us first endeavour to ascertain in what direction a congeries of this construction would be disposed to separate by the application of mechanical force.

We must premise one remark upon the difference of the power of attraction in the present instance and that of the spherical arrangement. In whatever way we place two spheres in contact, they will attract one another equally. But there is a material difference in the power of oblate spheroids. These latter will attract one another much more strongly when their shorter axes are in the same straight line, than when joined by their longer diameters. Intermediate degrees will be appropriate to the intermediate radii.

Let Fig. XVI. represent a section of a spheroidical arrangement held together by quadruple attraction, as in Fig. XV. if we suppose the force of a wedge applied between the

particles *c. f.* the latter will recede from the former. The motion which it thus acquires will be communicated to either *e.* or *h.* with which it is combined. But, in the first place, it is more strongly attached to *h.* than to *e.* on account of the radii which unite their centres being shorter in the former, than in the latter; and in the second place, for the same reason *h.* would be more easily removed from the attracting power of *e g.* than *e.* from the power of *b. c.* This then is the direction which the division would follow, and thus by mechanical force a combination of this nature would be alone divisible parallel to the planes of a regular rhombic parallelopipedon Chemical attraction, on the contrary, possesses a wider range of action, as explained in the spherical congeries, and accordingly we find, that carbonate of lime, by this agency not only presents the intersections of the rhomboid, but divisions parallel to the basis of the tetrahedron.

The explanation of all the diversity of modifications presented by carbonate of lime in its crystallization, presents a wide field of enquiry. The fact of identity of ultimate arrangement in all, must be deemed established, and it will be sufficient for our present purpose to shew, in one or two instances, the reference which they bear to the form of the integrant molecule.

If we suppose the spheroid *a.* removed from the summit of the rhomboid $a.\ b^2.\ b^3.\ b^1.\ c^2.\ c^3.$ the new face formed will of necessity present the angles of an equilateral triangle. This, we shall find, corresponds with a common truncation of this substance in nature: the new plane is at right angles to the axis of the crystal, and corresponds exactly to the third modification of Bournon's system.

Again, supposing the tetrahedron to be increased by another row of particles, and then the three corner ones to be removed, a hexahedral figure will be formed, which, being continued downwards in the same disposition, will furnish a six-sided prism, which will be terminated by three pentagons, whose angle at the summit is the angle of the rhomboid. This is another common modification of carbonate of lime.

These then are forms which belong exclusively to the

quadruple attraction of spheroids. The sextuple force likewise produces a series of distinct and peculiar properties. As the hexahedral prism is the result of the former, so the tetrahedral prism emanates from the latter. Let us shortly trace some of the properties of this arrangement.

Sulphate of magnesia, which we find gives by chemical dissection planes parallel to the sides of a flattened octohedron, is divisible by mechanical force into trihedral prisms, in the direction of the diagonal of the base, and this, therefore, is the primitive form ascribed to it in Haüy's system. In this, it differs essentially from the four-sided prism of the spherical construction. We shall better understand the difference by referring to the figures, and endeavouring to estimate the force by which the particles are retained in their respective situations. The argument is applicable to the octohedrons in both instances. Let us call the power of attraction in spherical particles 10. and we know that it is the same in every part, that one ball can come in contact with another. a^{20}. Fig. V. is retained in the horizontal direction by the contact of four others which will exert upon it a power of 40. In the direction of the diagonal of the square of the octohedron b^{20}. is retained by three a^{20}. b^{19}. b^{22}. equal to 30, but in the direction of the planes of the octohedron a^{20}. is only retained by b^{20}. and b^{22}. equal in power to 20. This then will be the direction in which a fracture will take place. In Fig. XIV. however, a different law of attraction prevails. The power increases or diminishes as the radii which connect any two of them lengthen or contract. We will suppose this power to be as 12. in the direction of the shorter axis, and as 4 in the longer. The spheroid a. is attracted in the horizontal direction by b^1. b^2. b^3. b^4. with which it is connected by radii intermediate between the two. The power, therefore, acting upon this particle will amount to 8×4, or 32. In the lateral direction it is held by the contact of b^2. b^4 in the direction of similar radii exerting a force of 16, while in the perpendicular direction although b^2 is in contact with three others a. b^1. b^4. yet this being in the direction only of the longer axes of the two latter, the whole power likewise

amounts to 16. A congeries, therefore, of this structure will split in the direction of the diagonal of its square into trihedral figures.

It has been stated that the octohedral arrangement of spheroids, will not furnish a regular rhombic solid, analogous to that furnished by a similar disposition of spheres. There is, however, a particular modification which can arise alone from a particle of a fixed and determined measure, which approaches in its nature to this figure. If we suppose the four corner spheroids removed from the octohedron, as in Fig. XIV. four rhombs will be formed in their place, which, with a certain relative proportion of the axes of the particles, will be equal to the four rhombs remaining of the original faces of the figure. The whole solid will then present two rhombic parallelopipedons joined together, or the regular dodecahedron, as in Fig. XVII. The proportion is as 5 to 4, and the angles of the resulting rhombs are 109°. 28′. 70°. 32′. This may possibly be the constitution of those bodies whose primitive form is described to be the dodecahedron, and is certainly a more simple figure than the same form arising from the spherical arrangement of which c^3, b^4. c^6. d^4. Fig. III. present one of the sides.

It remains now to make a few remarks upon the causes which may determine the external form of crystallized bodies. We have seen that crystallization does not necessarily include symmetry of outward shape, but that a mass of metal which has been melted in a crucible, and in cooling has adapted itself to its cavity, has its constituent particles as regularly arranged as the most mathematical figures of a crystallized salt.

No cause would appear to have a greater influence in this respect than the number of particles which are at once freed from the power of any solvent, and brought within the sphere of mutual attraction. This number, no doubt, varies with the medium.

The first impulse is derived from a compound attraction of a certain number of molecules for each other, prevailing over

the attraction of the fluid. The action is kept up by a disposing attraction, which directs the subsequent deposition of particles to certain points of the first formed nucleus. As one sphere cannot come in contact with more than twelve other similar spheres, the compound attraction must be limited to that number. If the number should exceed this, the nucleus would no longer be regular. This then is the boundary between symmetrical and amorphous crystallization; and the greatest number of particles in the former, range themselves in a hexahedral figure; which, as it has been demonstrated to be that mathematical form which, of all others, includes the greatest capacity under the least surface, might *a priori* have been determined to be the figure which they would have assumed in crowding into the least space. Of all solvents heat is that which removes the particles of bodies to the least possible distance, this distance being no more than just enough to produce fluidity, and the approximation, therefore, of the particles, when the agent is withdrawn, is immediate. When a melted metal is cooled, each atom being already surrounded by as many more as possible in the fluid state, they maintain nearly the same arrangement in assuming the solid form.

A singular confirmation of the spheroidical form of the ultimate particles of crystallized bodies, offers itself in the contemplation of a local arrangement which is common to crystals of every substance. If we suppose two nuclei to be formed in any solution, in such a manner that the axis of one shall run in a contrary direction to the axis of the other, each will of course attract a particular system of particles from the surrounding medium. Should the two, therefore, come in contact, a greater number will be collected at the point of junction, than at any other, and they will therefore arrange themselves in the least possible space. Accordingly we find, that whenever a crystal is attached to another, in such a manner, that their axes run in contrary directions, if we pull the two asunder, we shall invariably be presented with a regular hexagonal arrangement at the point of junction, whatever be the form of the crystal, the nature of the

substance, or the direction in which at any other part it would be disposed to separate by mechanical force. This observation has been repeatedly verified upon carbonate of lime, selenite, fluor-spar, quartz, topaz, and other mineral bodies.

The foregoing experiments and observations are offered in support of the ingenious theory of Dr. Wollaston, whose simple and satisfactory elucidation of the principles of crystalline arrangement has solved the difficulties, and remedied the inconsistencies of all previous explanations of the phenomena. Former hypotheses, however laborious in their construction, were defective, and unsatisfactory in the fundamental data of their arrangement, and were incompetent even to explain the solitary fact from which they originally emanated.

This, however, is found to stand the test of experiment, as far as it is applicable from the nature of the subject; and another analogy is thus opened to the admirers of the simplicity and beautiful connection of the order of the universe, who will recognize, in the invisible and scarcely imaginable atoms of a crystal, the same forms which in incomprehensible magnitude roll their majestic courses in the planatary system.

Art. IV. *An Account of a singular Malformation of the Human Heart.—By* Nathan L. Young, *Esq. F. R. M. S. E. &c.*

James Oswald, labourer, aged 49, of a sanguine temperament, was admitted into the Royal Infirmary of Edinburgh the 25th December, 1815. He laboured under Eczema Mercuriale*

* See Mr. Pearson's "Observ. on the effects of Var. Art. of the Mat. Med. in Lues Ven." chap. xiii. 2nd edit. Erythema Mercuriale. (See Dr. McMullins in the Edinb. Med. and Surg. Journal, vol. i. and ii.) Hydrargyria (see Dr. Alley's Observ. on the Hydrargyria, Lond. 1810.) Mercurial Lepra (see a treatise of Dr. Moriarty, of Dublin.).

accurately defined. The disease supervened on the application of the unguentum nitratis hydrargyri to the eye-lids, which were affected with lippitudo, and to an ulcer on the leg. In conjunction with the cutaneous affection, the pulse was very frequent, quick, and intermittent, and variable also in frequency and strength, the heat was natural; he complained of great depression of strength and of an imperfection of the sense of touch, and his countenance was rather pale.

The peculiar state of the pulse and great depression of strength, were considered to indicate a morbid condition of the system induced by mercury, and termed by Mr. Pearson, *Erethismus.*

Influenced by the above circumstances, the remedies employed were antimonials with opium, sarsaparilla, Peruvian bark, mineral acids, nutritive diet, and cold air; by this treatment the cutaneous affection gradually got better, and before the fatal termination of the case, was almost completely cured, but the irregularity of the pulse and depression of strength continued: the pulse, however, at times became more regular and strong. On the 14th January, 1816, he had a severe febrile attack, attended with cough, difficult breathing, and universal pains, and enlargement and tenderness, stretching from the right hypochondrium to the epigastrium, which was conjectured to indicate some hepatic affection.* The febrile state was removed by a mild antiphlogistic regimen, but the other symptoms continued, and became aggravated

* The pathognomonic symptoms of diseases of the heart are as yet little understood, however much has been lately added to our knowledge on this subject, by the valuable publications of M. Corvisart and Dr. Farre. Many are the cases on record, the diagnoses of which were confuted by dissections. (See Dr. Farre's Patholog.) A case is recorded in the London Med. Repository, vol. ii. p. 124, which had been considered to be a case of hepatitis. Dr. Duncan's three cases of Carditis, in the 45th No. of the Edinb. Med. and Surg. Journal, one of which was taken for a case of hysteria in the male, and the other two for inflammation of the pleura and lungs. Many other cases of the same kind may be referred to, but it would be irrelevant to the intention of this communication.

a day or two before his death, which took place unexpectedly, on the 23d inst.

On examination after death, the right cavity of the pleura was found to contain about sixteen ounces of a reddish fluid, and the upper lobe of the lung on this side shewed that recent inflammation had existed: the lung of the left side adhered generally to the pleura costalis, and the adhesions appeared old.

Ten ounces of a very red and turbid fluid were effused into the pericardium, with detached portions of coagulable lymph floating in it. The serous membrane of the heart, where it covered the appendix of the right auricle and a portion of the anterior parietes of this cavity, indicated recent inflammation, and the pericardium opposite to this part of the heart was also in the same morbid state. The heart was about twice the natural size, for a man of about five feet six inches, which was the stature of this subject. It weighed, when freed of the coagula, which were in great abundance in this case, and with its vessels cut short, twenty-eight ounces and forty-four grains. The auricles were found to form one extensive cavity, by a complete dilatation of the foramen ovale,* for the columnæ foraminis ovalis were distinctly seen, and the opening measured three inches and a half in diameter. The cavæ and pulmonary veins were enlarged in proportion to the size of the cavity; the valve of Eustachius and the great coronary vein were also much larger than usual, for the index finger could with ease be introduced into the opening of the vein: the parietes of this cavity were very thin in proportion to its size. The size of the pulmonary ventricle and the thickness of its parietes agreed with the size of the heart; and its ostium was two inches and a half in diameter: the valvula tricuspis was ossified in some parts and in others very much thickened; the pulmonary artery much larger than the aorta, and greatly exceeding the natural size; its semilunar valves were completely ossified, leaving a very irregular and contracted opening,† in some parts half an inch, in others less, in diameter. The cavity of the aortic ventricle was of a natural size, but its parietes were much thicker than usual,

* See the plate. † Plate.

and its ostium was an inch and a half in diameter: the valvula mitralis was quite natural: the semilunar valves of the aorta were a little thickened, the aorta itself and its branches, which were exposed in the course of the dissection, were perfectly natural.

The abdomen contained nearly sixteen ounces of a straw coloured fluid; the liver was paler, but neither harder nor larger than usual; the other viscera of this cavity were natural.

Observations. The above morbid phenomena induced me to make a strict enquiry into the history of this man previous to his admission, the particulars of which are, that during the last eighteen years, he has had several attacks of inflammation of the viscera of the thorax; that four years ago, he had a slight apoplectic attack, which completely deprived him of his wonted activity and vigour, and left a sensation of numbness over the whole body,* hence, we must regret that the brain was not examined, for probably some morbid appearances would have been found: I also learnt that he had never a livid complexion; nor could any other symptoms be ascertained which would have led us to suppose a diseased heart existed, except the peculiar state of the pulse, and for what time this had continued could not be learnt: this state, for reasons already mentioned, was considered to have been induced by mercury absorbed into the system. The heat was frequently taken, and it varied from 97° to 101° of Fahrenheit, the thermometer being placed in the axilla, which I have generally found to measure a degree and a half less, and in calculation more certain, than if placed under the tongue. He frequently complained of coldness of the extremities, but his surface never felt morbidly cold.

I am not aware that we have on record any case of such extensive disease of this very important organ, accompanied by so few characteristic symptoms, as this which I have

* An accident occurred to illustrate the morbid sense of touch, for having given him a glass vessel, he grasped it so violently as to break it into pieces.

related. A late publication* to which I have referred in a preceding part of this case, in which a classification of malformations of the heart is given, and under which the most important cases of malformations of this organ are collected, gives us the best example of this kind, "Dilated foramen ovale and contracted ostium arteriæ pulmonalis," a case from Morgagni, in which also the form of the heart was not natural: "Cor habuit exiguum, et mucronem versus, quasi subrotundum. Ventriculus sinister forma erat qua solet dexter, et dexter vicissim qua sinister; et quamquam hoc latior, parietibus tamen crassioribus. Dextera pariter auricula tota duplo erat grandior, quam tota sinistra, duploque carnosior. Inter utramque etiam tum patebat foramen ovale, ut minimum digitum posset admittere. De tribus valvulis triangularibus justam una magnitudinem; duæ reliquæ minorem habebant. Sigmoides autem quæ pulmonaris arteriæ ostio præficiuntur, ad basim quidam erant secundum naturam; sed parte superiore cartilagineæ videbantur; quem exiguum ossis frustulum jam habebant: erantque ea parte sic inter se colligatæ, ut vix foramen relinquerent, lente non majus, per quod sanguis exiret."† This inimitable author having so ably stated the morbid phenomena, as above, proceeds in the thirteenth section to explain their influence on the circulation; the conclusions are perhaps not completely satisfactory.

Considering the above facts, I am led to these particular considerations, but as it is my intention to treat the subject more extensively at some future period, I shall at present only advance them as *queries*.

What must have been the action of the heart in this case, so as to keep up that equable circulation which existed for such a length of time,‡ in defiance to the extensive malformation?

* Dr. Farre's Patholog. Resear. on Malf. of the Human Heart.

† Vide Morgagni De Sed. et Causis Morb. Epist xvi. 12, et seqq. 13.

‡ That the malformation existed from birth cannot be doubted, but it is very probable that it was rapidly increased by the frequent inflammatory affections of the thorax which he was said to have experienced.

Does the "morbus cæruleus" depend on admixture of venous and arterial blood? What portion of venous blood is requisite?

Is it not more probable that the "morbus cæruleus" depends on languid circulation?

Is the ductus arteriosus generally found pervious in cases of the "morbus cæruleus," in combination with open foramen ovale?

Is it necessary that the ductus arteriosus and foramen ovale be open in the same subject, to constitute this disease?

Is it not probable, that a slow circulation through the lungs, which must have taken place in this case, may give rise to superoxygenation of the blood, and hence the effect of admixture of venous and arterial blood be obviated?

Is there not an equilibrium in the action of the cavities of the heart, which in some cases of malformation compensates for natural structure, and which, as soon as it is subverted, gives rise to symptoms indicative of morbid structure?

Lastly, What are the pathognomonic symptoms of this malformation, or complete dilatation of the foramen ovale, contracted ostium arteriæ pulmonalis, and extensive enlargement of the heart?

Explanation of the Drawings.

FIG. 1st. Presents a full view of the right side of the heart.

a The superior vena cava.

b The ascending aorta.

c The appendix of the right auricle, much enlarged and altered in shape.

d The inferior vena cava.

e e The right auricle. It is cut open and its outer section stretched out.

f The dilated foramen ovale.

g Leads to the ostium ventriculi.

h An aperture from the auricle into the appendix.

i An opening into the coronary vein.

k The valve of Eustachius.

l l l The right ventricle.

FIG. 2d. A view of the anterior part of the pulmonary artery and the irregular opening into it.

a The pulmonary artery.

b b The semilunar valves completely ossified.

c c The ostium arteriæ pulmonalis.

N. L. YOUNG.

Edinburgh, 24th February, 1816.

ART. V. *Some Account of the external Changes which take place in the Surinam Frog* (Rana Paradoxa *of* LINNÆUS), *from its earlier Stages till it becomes a perfect Animal. By* W. M. IRELAND, *Esq. Member of the Royal College of Surgeons; with Remarks upon its internal Structure by Sir* E. HOME, *Bart.*

IT is a curious circumstance that it has never been in the power of any naturalist at Surinam, from his own observations, to ascertain the changes from the tad-pole to the complete frog of that country.

Fortunately during my residence there I was not only enabled to collect specimens of the tad-pole in what is called the state of a fish, but likewise in all its intermediate changes to that of a frog, and have succeeded in bringing to this country specimens in each of those states, for the examination of persons skilled in comparative anatomy, so as to enable them to confirm or refute the observations I have made on the subject.

Linnæus himself, at one time, considered the animal to be a species of lizard, and arranged it under the genus *Lacerta*, afterwards he placed it under the genus in which it now stands, with the specific name *Piscis.*

By others it has been considered not to be the larva or tad-pole of a frog, but to change from a frog to a fish: this diversity of opinions first induced me to attempt the solution of so curious a phenomenon.

It affords me peculiar gratification that I am enabled to offer some facts which will tend to throw light on this part of natural history, the subject of which has caused so much discussion among the learned.

I was some time in Surinam, where these animals are indigenous, before I could obtain a specimen; at length, however, I procured a number of them in the fish state, and as they were brought to me alive, I confined them in a tub in order to watch their change, and contrived to have vegetables growing in the water, for the purpose of renovating its air.

When they first came into my possession I could, upon narrow examination, perceive the two small legs immediately behind the head, which are to become the hind legs of the frog, as shewn in Fig. I.

In about a fortnight these little legs arrive at the size represented in Fig. II. and the body of the animal is very much enlarged: during this change the animal remains at the bottom of the vessel in a torpid dormant state.

In about three weeks the animal becomes more active and lively, and the fore legs make their appearance, and the head becomes distinct, as in Fig. III. During this period the animal remains suspended in the water, with its mouth above the surface, for the purpose of breathing atmospheric air; but the moment it perceives any thing move it dives to the bottom, where it remains a few minutes and then returns to its former position.

From this period till about the sixth week the animal is always seen with part of its head above the surface of the water, and is extremely active and strong, so much so, that should the vessel be left uncovered for half a minute it leaps out and jumps six or eight feet at a time, with such quickness that it is with great difficulty caught again. During this last period of the change the tail, or that part which is behind the legs, partly sloughs off and is partly absorbed; that is, the outer and thin part of the tail gradually falls off by bits, while the inner and thicker part is absorbed, till the whole is gone to the line marking the part which is to be separated.

This process being completed, the animal is a perfect frog, and leaves the water never to return.

The transformation of the tad-pole to a frog, seems to be one of the never-erring laws of nature to propagate and preserve her progeny; for at the beginning of the dry season, the tad-poles are to be found in most of the swamps and muddy creeks; but as the dry season advances and the water begins to evaporate, those tad-poles, which must inevitably die (if they remain unaltered) when their habitation is changed to dry land, gradually become animals fitted to exist in these new circumstances.

It must be observed, that the tad-poles cannot follow the waters as they retire, in the same way fishes do in our small brooks in a dry summer, owing to their being many miles from any communication with the rivers, so that when the inclosed waters are evaporated by the intense heat of the season, the bottom of those ponds and creeks are left a perfect dry land.

These tadpoles are considered by the natives of Surinam as a species of fish, and denominated by them Jackies. They are frequently brought to market in the beginning of the dry season, and generally regarded as a great delicacy for the table. The size is commonlv from six to eight inches long. None of the natives seem to be acquainted with their transformation, and those who saw them in their different stages of actual change, could never afterwards be persuaded to eat them.

W. M. IRELAND.

Mr. Ireland having allowed me permission to examine the specimens of the Surinam frog from the tad-pole state nearly to that of the perfect animal, to ascertain the internal changes which it undergoes, with the assistance of Mr. Clift I was enabled to make out the following curious mutations in the internal structure. In the stages comprehended between Fig. I and Fig. II. the intestines increased in size and length so as to fill up the large cavity which may be said to constitute the body of the animal, except that part imme-

diately behind the mouth where the gills are situated. As the structure of the gills and the convolutions formed by the intestines are represented in the annexed plate, it is not necessary to give a verbal description of them, although it is proper to remark that the gills, which are three in number on each side, are supplied with water by the mouth, which is afterwards allowed to escape by one aperture only, situated on the left side of the body a little behind and below the eye, as represented in the plate.

In this stage, the rudiments of the lungs are readily detected in a very small form in the posterior part of the abdomen, behind the liver. When the animal has arrived at the stage represented in Fig III. the intestines have undergone a considerable diminution of their capacity, and I may venture to say, a wonderful diminution in their length. The whole of the cavity of the abdomen, except what is occupied by the liver and intestinal canal, was completely filled with fat. The appearance of the lungs in this stage, as well as that of the stomach and intestines, is shewn in the plate.

The observations which arise from the consideration of these very curious changes are not sufficiently matured to allow me further to enter into them upon the present occasion.

EVERARD HOME.

Explanation of the Plates.

Fig. I. Tad-pole of the Surinam frog in that stage in which the natives consider it to be a fish; but when accurately examined the rudiments of the hind-legs are readily distinguished making their appearance externally.

Fig. II. Tad-pole still further advanced; the hind-legs considerably more advanced, the cavity of the abdomen greatly enlarged to contain the extended intestinal canal. Immediately behind and below the eye is seen the aperture of the gills, which only exists on the left side.

Fig. III. The tad-pole with the fore-legs exposed. The tail and cavity of the abdomen both reduced in size, and the mouth of the frog having acquired its natural shape.

Fig. IV. The tad-pole in its last stage before the tail is thrown off: its body much reduced in size.

Fig. V. A view of the intestinal canal in the tad-pole, to shew the manner in which it is coiled up, and the rudiments of the lungs upon the posterior part of the abdomen as they were observed in the specimen represented in Fig II.

Fig. VI. The appearance of the stomach and intestinal canal taken from the specimen represented in Fig. III.

ART. VI. *An Account of the physical and chemical Properties of the Malambo Bark, as described in two Memoirs of Messrs* Cadet *and* Vauquelin, *and in a Report made to the Supreme Junta of Carthagena, in America. By* A. B. GRANVILLE, *M. D. M. R. C. S. and Foreign Sec. G. S.*

History.

THE Malambo bark, which the French have lately introduced into their materia medica, was first publicly noticed, described, and analysed by Mons. Cadet, an apothecary of great eminence, in a memoir published in 1815. Mons. Cadet had received a quantity of this bark from Bonpland, the celebrated travelling companion of Baron Humboldt, who had brought it from South America, where it was known by the inhabitants of Choco under the name of "Palo de Malambo."

Mons Bonpland expressed a wish that this bark should be properly examined and analysed; and informed Mons. Cadet, that although it had been supposed, by some enlightened men in America, to belong to the genus *Cinchona,* he had reason to believe this to be a mistaken notion, particularly when the peculiar texture and flavour of the bark were taken into consideration. This conjecture was soon afterwards converted into a certainty, from Mons. Bonpland having had an opportunity of seeing large collections of the bark at *Popayan* and *Quindiu,* from whence they were to be sent to Carthagena for sale. On inspecting several specimens of it, he remarked some in which the alternate insertion of the leaves *(folia*

alterna) were too evident to admit of their being numbered among the *rubiacées* of Jussieu, of which the Cinchona is one. Prevented however from more closely examining the essential characters of the tree to which the bark in question belongs, Mons. Bonpland thinks it safer to affirm nothing very positive respecting it, and simply ventures to say that a very great analogy exists between the Malambo and the *quassia*, or even the *Trifolia Bonplanda* of Willdenou, on account of the extreme bitterness of its taste. This is, however, too superficial a character to be taken into consideration, as a determining feature in the classification of a new plant.

M. Zea, a Spanish botanist of great eminence, and a native of Antiochia in the province of New Grenada, happening to be at Paris when the Malambo bark was brought thither from America, instantly recognized it as belonging to a tree of which, in his youth, he had seen a great number in his native country. From all he had been able to collect respecting it, although he was not then able to determine its genus, he was quite satisfied that it belonged to the family of the *Magnolia*, and most probably to the genus *Wintera*. In fact, the Malambo bark bears the greatest resemblance, whether in point of external characters or of flavour, to that of the *Wintera aromatica*.

The Malambo grows very adundantly in the provinces of Choco and Antiochia in New Grenada. It is found even in some mountains where the air is temperate; but rather cool than warm. In the province of Antiochia it is called *Arbol de Agi*, on account of its burning and caustic taste—the word *agi* being in that country used to design the hottest *capsicum*.

In a report made to the supreme junta of the province of Carthagena *(informe del real consulado de Carthagena de las Indias etc. ano de* 1810) it is said " that the Malambo is found abundantly in the province of Santa Martha, from whence it is imported in large quantities to the Havanna, where it is much and successfully employed in the treament of *Trismus*, a disease to which the negroes in that island are frequently subject. No case of death has occurred from this disease since the introduction of the Malambo bark as a remedy against

it; and we think that government ought to direct its attention to a vegetable which promises besides many other useful applications from the aromatic smell, the colour, and the flavour of its bark."

Although these facts are far from enabling us to form an exact idea of the plant which furnishes the Malambo bark; yet they are sufficiently numerous, and, no doubt, accurate enough for the botanist to furnish us, at no great distance of time, with a complete history of the nature and origin of this interesting vegetable.

The novelty of the subject, and the prospect of its becoming, shortly, an object of attention with physicians, on account of the great benefit likely to result from its application to the healing art, induced Vauquelin to undertake the chemical analysis of the bark, notwithstanding the one already published by Mons. Cadet in the *Journal de Pharmacie* for January 1815, from which that of Mons. Vauquelin differs in some trifling respects.

The following is a translation of the latter taken from the *Annales de Chimie*, November, 1815, preceded by a slight sketch of the physical properties of the bark, described by Cadet in the memoir above alluded to.

Physical Properties.

The Malambo bark is of an ash-red colour with a grayish coloured epidermis covered with protuberances more or less prominent, of a dirty white tint.

It differs in thickness from four to five millimetres (1.999 inch) including the epidermis.

Its smell is strong; it reminds one of that of some species of pepper, and greatly resembles that of *Calamus aromaticus.*

Its taste is bitter, hot, and pungent; it long continues in the mouth, perfuming it strongly, and leaving a very sharp impression on the tongue.

The *epidermis* seems to be more aromatic than the *liber*, while this is more bitter than the former.

This bark, however dry, is not easily pulverized. Exposed to the air it soon becomes moist, and rolls itself up into small lumps.

Chemical Analysis.

Exper. I. One hundred grammes (3 oz. 8,5 drams) of the bark coarsely pulverized, were treated with one thousand grammes (2℔. 3oz 5 drams) of boiling water in a retort to which a proper receiver had been adapted. After drawing off, by distillation, about half the quantity of the water employed. the operation was stopped. On the surface of the distilled water a certain quantity of a slightly yellowish oil was found, and separated by means of a capillary glass funnel. It weighed about a gramme (15.5 grains). The water was rather milky, with a smell and taste evidently derived from part of the oil it had retained in solution.

Exper. II. The remaining water in the retort, after having been filtered and evaporated, gave a red-brown viscid extract, on which alcohol, even when boiling, had but little action: it, however, separated from it a small quantity of a bitter matter. The insoluble portion which, while hot, was viscid, became dry and brittle when cooled: it had scarcely any bitter taste left, and weighed two grammes (31 grains).

After having been thus treated with alcohol, the red-brown extract was completely re-dissolved in water; its solution, however, was not very limpid, and after rest, it deposited a small quantity of a yellowish white powder.

Exper. III. After allowing the coarsely pulverized bark of the Malambo, treated with water, (Exp. I.) to dry; it was submitted to the action of boiling alcohol for an hour, when the latter had acquired a deep brown colour.

The alcohol was then evaporated in close vessels, and left a brown matter, which, when cold, was dry and brittle, weighing about 7 grammes (108.5 grains).

The alcohol obtained in this last distillation gave out a faint smell similar to that of the bark, particularly when diluted with a certain quantity of water, which gave to it, besides, a milky appearance. This proves that not all the volatile oil had been drawn off in the former distillation of the bark with water. But if the bark be treated in the first instance with alcohol, a more aromatic spirit is obtained, by which water is rendered milky in a much greater degree.

The above experiments prove, at once, that the Malambo bark contains principally three substances, viz.

1st, An aromatic volatile oil.

2nd, A highly bitter resin.

3d. An extractive matter soluble in water.

Let us now examine the principal properties of the products obtained from the Malambo bark.

Chemical Properties
of the Products obtained from the Malambo Bark.

A. *Resin.* It is of a red-brown colour, dry, brittle, and brilliant in its fracture; when first put into the mouth it appears without taste; but in a short time its bitterness developes itself with much intensity. It is highly soluble in alcohol, particularly when warm, from which solution water throws down an abundant precipitate. It is insoluble in alkalies. Placed on a heated iron plate it is gradually and almost wholly resolved into smoke, emitting a fragrant smell not unlike that of frankincense.

When exposed to a high temperature in close vessels, it gives out water having an acid taste; a dense oil, the smell of which is by no means agreeable; and charcoal of a small volume.

B. *Extractive Matter.* Its colour is a yellow brown; brittle when perfectly dry, but gradually becoming soft when exposed to the air, the moisture of which it absorbs. When well washed with alcohol its bitter taste entirely vanishes; and while moist it is viscid and glutinous.

When exposed to heat in close vessels, this extract gives out brown oil, an aqueous fluid which reddens litmus, from which, however, potash disengages ammonia in a very marked manner.

The charcoal left in the retort, when burnt in a platina crucible, produced some strongly alkaline ashes, which gave, after lixivium, a considerable quantity of sub-carbonate of potash of a green colour, similar to that of the potash of commerce. This colour is owing to manganese; for on saturating with muriatic acid the alkaline solution, it assumed a beautiful rose colour.

The alkali in question proceeds no doubt from some salts not soluble in alcohol, and present in the Malambo bark, such as the tartrate, citrate, or oxalate of potash.

C. *Volatile Oil.* It has a light lemon colour, with a smell nearly allied to that of pepper and of thyme. It is lighter than water, and slightly soluble in that fluid, to which it imparts its own smell, and acrid and pungent taste. It is highly soluble in alcohol.

D. *Combustion of the bark after having been treated both with alcohol and water.* When the Malambo bark, after having undergone the various operations already described, is properly burnt, there remains some yellowish white ashes, entirely soluble with effervescence in muriatic acid, and from which ammonia precipitated a little phosphate of lime mixed with a small portion of iron. When sulphuric acid is added to the solution, and the solution itself evaporated to dryness and then calcined, much sulphate of lime is obtained with a little sulphate of magnesia, and an inconsiderable quantity of magnesia.

Reflections.

The principle most abundant in the Malambo bark is the resinous matter, since it forms the fifteenth part of the whole. It is this matter which gives the bark its bitter taste, and in which, no doubt, exists the principal virtue of the bark.

The volatile and aromatic oil which accompanies the bitter principle, inclines us to hope that the bark in question will prove a very useful addition to the class of tonics of the materia medica. But the resin being very abundant, and the volatile oil extremely pungent, it will be necessary to exhibit the bark in small doses at first.

The bark on which the preceding analytical inquiries were instituted was, like that of Mons. Cadet, obtained from Mons. Bonpland, who had brought it from America.

Art. VII. *Account of a new Blow-pipe, in a Letter from Mr.* John Newman *to the Editor.*

SIR,

As I conceive you must feel interested by every thing connected with science, I take the liberty of sending you a short description of an instrument calculated to lessen the fatigue attending some of the researches of an experimental philosopher. The common blow-pipe is an instrument which though of great value to the operative chemist, has many defects. Whilst in use it confines the motions of the person working with it, and renders him incapable of giving that minute attention to his experiment which is often required, and its application is confined, since by means of it the breath only can be employed to produce the required effect.

To obviate these and other disadvantages has been the object of many persons, and by adapting apparatus to the simple instrument they have endeavoured to make it more complete and perfect. Some of these improvements are calculated to leave the operator unengaged with the immediate care of the instrument, and others enable him to feed the flame with such gazeous matter as will increase the combustion and exalt the temperature, but they have in general, I think, either rendered the instrument more bulky, and consequently inconvenient; or more intricate and subject to derangement. I have long thought the blow-pipe capable of much improvement, but it was an object also to preserve its simplicity; I flatter myself that without lessening the latter, I have added something to the perfection of the instrument.

Having frequent occasion to condense the air in cavities, I had observed with some surprise the length of time required by the air so confined to escape through such small apertures as might exist, or were purposely made into these cavities, and in conversation with Mr. Brooks he suggested, that if the stream were tolerably equable, the principle which gave rise to such an effect might be followed with advantage in the construction of a blow-pipe, and I have since verified this idea.

The instrument I have made consists of a strong plate copper box perfectly air tight, three inches in width and height, and four in length, a condensing syringe to force air into the box, and a stop-cock and jet at one end of it to regulate the stream thrown out. The piston-rod of the condenser works through collars of leather in the cap, which has an aperture in the side and a screw connected with a stop-cock, which may again communicate with a jar, bladder, or gazometer containing oxygen, hydrogen, or other gasses. This communication being made, and the condenser being worked, any air that is required may be thrown into the box and propelled through the jet on the flame.

The use of the instrument is very simple. By a few strokes of the piston the air is thrown into the chamber and forms a compressed atmosphere within it. When the cock is opened the air expanding issues out with great force in a small but rapid stream, which, when directed on the flame of a lamp, acts as the jet from a common blow-pipe, but with more precision and regularity. The force of the stream of air is easily adjusted by opening more or less the small stop-cock, and I have found that with a moderate charge it will remain uniform for twenty minutes; opening the stop-cock, or the use of the syringe, will immediately raise it to its first strength.

These blow-pipes are very portable, not liable to injury, and answer, I believe, the expectations of all who have tried them, and I have made many of them for different persons. The whole instrument, with a lamp adapted to it, packs up in a small box not more than six inches in length and four inches in width and height, and there is enough space left for other small articles. I have fitted up boxes rather larger in size with a selection of tests and other useful articles in addition to the blow-pipe, and in this state they form complete mineralogical travelling cabinets.

I am, Sir,

Your obedient humble servant,

JOHN NEWMAN.

Philosophical Instrument Maker
No. 7, Lisle-street, Leicester-square.

Art. VIII. *On Aqua–regia, or Nitro-muriatic Acid.* *By Sir* H. Davy, *LL.D. V.P.R.I. F.R.S. &c.*

If strong nitrous acid, saturated with nitrous gas, be mixed with a saturated solution of muriatic acid gas, no other effect is produced than might be expected from the action of nitrous acid of the same strength on an equal quantity of water; and the mixed acid so formed has no power of action on gold or platina.

Again; if muriatic acid gas and nitrous gas in equal volumes be mixed together over mercury, and half a volume of oxygen be added, the immediate condensation will be no more than might be expected from the formation of nitrous acid gas. And when this is decomposed, or absorbed by the mercury, the muriatic acid gas is found unaltered, mixed with a certain portion of nitrous gas.

It appears then, that *nitrous* acid and muriatic acid gas have no chemical action on each other.

If *colourless nitric acid* and muriatic acid of commerce be mixed together, the mixture immediately becomes yellow, and gains the power of dissolving gold and platinum. If it be gently heated, pure chlorine arises from it and the colour becomes deeper; if the heat be longer continued, chlorine still rises, but mixed with nitrous acid gas, which is much more absorbable by water, and which may be separated from the chlorine by a small quantity of water. When the process has been very long continued till the colour becomes very deep, no more chlorine can be procured from it. It loses its power of acting upon gold and platinum, and nothing rises from it but a mixture of nitrous acid and muriatic acid.

It appears then, from these observations, which have been very often repeated, that nitro-muriatic acid owes its peculiar properties to a mutual decomposition of the nitric and muriatic acid; and that water, chlorine, and nitrous acid gas are the results: and the attractions which produce these results, appear to be the attraction of oxygen for hydrogen to form water, and that of nitrous acid gas for water.

The correctness of these conclusions are still further proved by the circumstance, that though nitrous gas and chlorine have no action upon each other when perfectly dry: yet if water be present, there is an immediate decomposition, and nitrous acid and muriatic acid are formed.

It is easy to calculate the quantity of chlorine produced in nitro-muriatic acid by the doctrine of definite proportions. For every 101 parts in weight of nitric acid, equivalent to 118 parts in weight of hydro-nitric acid decomposed, 67 parts of chlorine must be produced.

The knowledge of the nature of aqua regia will explain many peculiarities of its action upon metals and alkalies. It does not oxidate gold and platina, but merely causes their combination with chlorine; and when it produces neutral salts, they are mixtures, and not chemical combinations of nitrates and compounds of chlorine.

M. Berthollet, with his usual sagacity, long ago stated that the nitro-muriatic acid owed its peculiar properties to the production of chlorine;* and, in substituting the theory that it is a simple, for the hypothesis of its being a compound body, his conclusions will be found in perfect harmony with those I have drawn.

M. Berzelius,† in a letter written in a tone wholly unworthy of a chemist of so exalted a reputation, has asserted that azotane, or the detonating compound of chlorine and azote, is *dry nitro-muriatic acid.* It is difficult to discover what meaning he attaches to this term; and it is wholly unnecessary to refute so unfounded and vague an assertion.

* Chem. Stat. English Translation, vol. II. page 179.
† Thomson's Annals, vol. VI. p. 47.

ART. IX. *On the Freezing of Wine; and on the Detection of an Error committed by* VAUQUELIN *respecting the specific Gravity of diluted sulphuric Acid. By* SAMUEL PARKES, *F.L.S. M.G.S. &c. in a Letter to the Editor.*

SIR,

MY assertion, on the authority of Virgil and Ovid, that the cold in some parts of Germany was formerly so intense, "that the people living on the banks of the Danube were accustomed to cut out their wine with hatchets, and to deliver it to their guests in solid portions,"* having raised doubts in the minds of several intelligent persons, who have spoken and written to me on the subject, I availed myself of the severe frost which occurred during the last month, to put the possibility of the circumstance to the test of actual experiment; and if you think the particulars worth recording, I shall be glad to see them inserted in the first number of the Journal of Science and the Arts.

On the 8th of February, I exposed an indefinite quantity of good old port wine in a covered tea-cup, and another tea-cup full of good sherry, to the cold of a very sharp night, and when I examined them on the morning of the 9th, I found the following proportions of the wine were frozen into very beautiful hard scaly crystals.

Port wine frozen	560 grains.
Ditto still liquid	580 grains.
Sherry wine frozen	288 grains.
Ditto remaining liquid	1056 grains.

When the frozen wine was examined, the temperature of the place where it stood was 22° below the freezing point. On tasting the frozen part of each kind of the wine, I could not distinguish, nor could the persons who were with me, any difference in the strength or flavour of the parts which were frozen, and those which still continued liquid, except that we thought the fluid portions were more vapid than those which were in the state of ice.

* See Chemical Essays, vol. I. page 118.

I was very desirous of continuing to prosecute the inquiry, but the change which immediately took place in the weather, prevented me. However, from the success of this one experiment, I am induced to conclude, that in a more intense cold, the whole of the wine would have been frozen into solid masses; and that therefore the accounts which Virgil and Ovid have given respecting the wine of ancient Germany, ought not to be treated as fabulous, but as true history.

Those persons who are in possession of a set of the *Annales de Chimie* may perhaps be glad to be informed how to correct an error which Vauquelin has committed, respecting the specific gravity of diluted sulphuric acid. In a table which this eminent chemist published in the 76th volume of this work, page 260, he has stated, that the diluted acid of the specific gravity of 1.023 contains 6.600 per cent. of concentrated acid of the specific gravity of 1.842 and 93.400 of water; whereas, on repeating the experiment with the utmost care, I found that such diluted acid contains only 3.069 of acid of the specific gravity he mentions, and 96.931 of water. To ascertain this I proceeded in the following manner.

I took 66 drachms of concentrated sulphuric acid, sp. gr. = 1.842, and having carefully mixed it with 934 drachms of pure water, (both by weight,) I left the mixture at rest 48 hours for a complete combination to be effected, and then found its specific gravity at 60° of Fahrenheit, to be 1.0474 instead of 1.0230, as Vauquelin had stated. Pursuing the experiment, I added 300 drachms more of water. This reduced it, after standing 20 hours, and occasionally agitating it, to 1.0311.; 500 drachms more of water reduced it to 1.0243, and it required still 50 drachms of water to bring it to the specific gravity of 1.0230. So that this quantity of concentrated acid, instead of taking 934 drachms of water, actually requires 2084 drachms of that fluid to reduce the acid to the specific gravity in question, *viz.* that 1.0230.

Those persons who are in possession of Tome 76 of the

Annales de Chimie, should therefore correct No. 12 in the first table, page 260, Acide à 5° in the following manner.

Sulph.	3.069
Eau	96.931
	100

I examined the other parts of Vauquelin's table, and found the whole of it correct, except in this one instance; or, at least, sufficiently so, for every purpose of real business.

With great respect,

I am, dear Sir,

Your's very truly,

SAMUEL PARKES.

Goswell-street, 12th March, 1816.

ART. X. *Observations on the Application of Coal Gas to the Purposes of Illumination. By* WILLIAM THOMAS BRANDE, *F.R.S.L and E. Prof. Chem. R.I &c.*

THE employment of the gases evolved during the destructive distillation of common pit coal for the illumination of streets and houses, is a subject of such intrinsic and increasing importance, as to render some account of its progress and improvement a proper subject of discussion in this Journal.

That coal evolves a permanently elastic and inflammable aeriform fluid seems first to have been experimentally ascertained by the Rev. Dr. Clayton, and a brief account of his discovery is published in the Philosophical Transactions for the year 1739. The following is an extract from his paper. "I got some coal, and distilled it in a retort in an open fire. At first there came over only phlegm, afterwards a black *oil*, and then likewise a *spirit* arose, which I could no ways condense; but it forced my lute, or broke my glasses. Once when it had forced my lute, coming close thereto in order to try to repair it, I observed that the spirit which issued out, caught fire at the flame of the candle, and continued burning

with violence as it issued out in a stream, which I blew out and lighted again alternately, for several times. I then had a mind to try if I could save any of this spirit, in order to which I took a turbinated receiver, and putting a candle to the pipe of the receiver whilst the spirit arose, I observed that it catched flame, and continued burning at the end of the pipe, though you could not discern what fed the flame. I then blew it out, and lighted it again several times; after which I fixed a bladder, squeezed and void of air, to the pipe of the receiver. The oil and phlegm descended into the receiver, but the spirit still ascending blew up the bladder. I then filled a good many bladders therewith, and might have filled an inconceivable number more, for the spirit continued to rise for several hours, and filled the bladders almost as fast as a man could have blown them with his mouth: and yet the quantity of coals distilled was inconsiderable.

"I kept this spirit in the bladders a considerable time, and endeavoured several ways to condense it, but in vain. And when I had a mind to divert strangers or friends, I have frequently taken one of these bladders, and pricking a hole therein with a pin, and compressing gently the bladder, near the flame of a candle till it once took fire, it would then continue flaming till all the spirit was compressed out of the bladder: which was the more surprising, because no one could discern any difference in the appearance between these bladders, and those which are filled with common air.

"But then I found that this spirit must be kept in good thick bladders, as in those of an ox or the like; for if I filled calves' bladders therewith, it would lose its inflammability in twenty-four hours, though the bladders became not relaxed at all."

But the application of the gas thus generated to the purposes of economical illumination, is of much more recent date, and the merit of introducing it is principally due to Mr. Murdoch, whose observations upon the subject are published in the Philosophical Transactions for 1808. He first tried it in Cornwall, in the year 1792; and afterwards in 1798 established an apparatus upon a more extended scale at Boulton and Watts' foundry at Birmingham; and it was there that the

first public display of gas lights was made in 1802, upon the occasion of the rejoicings for peace. These, however, were but imperfect trials, when compared with that made in 1805 at Messrs. Philips and Lee's cotton mills at Manchester; and upon the results of which, all subsequent procedures, with regard to gas lighting, may be said to be founded. The whole cotton mill, with many adjacent buildings, were illuminated with coal gas to the exclusion of lamps, candles, and other sources of artificial light. Nearly a thousand burners of different forms were employed; and the light produced was estimated equal to that of 2500 well managed candles of six to the pound.

The most important and curious part of Mr. Murdoch's statement, relates to the cost of the two modes of lighting (namely, by gas and candles,) per annum. The cost of the coal used to furnish the gas, amounting annually to 110 tons, was 125*l.* Forty tons of coals to heat the retort, 20*l.* and the interest of capital sunk, with due allowance for accidents and repairs, 550*l.* From the joint amount of these items, must be deducted the value of seventy tons of coke, at 1*s.* 4*d.* per cwt. amounting to 93*l.* which reduces the total annual expense to 602*l.*; while that of candles to give the same light, would amount to 2000*l.*

Such was the flattering result of the first trial of gas illumination upon a tolerably extensive scale. In regard to its efficacy, we are informed by Mr. Murdoch, that the peculiar softness and clearness of the light, with its almost unvarying intensity, brought it into great favour with the work people; and it being free from the inconvenience of sparks, and the frequent necessity of snuffing, are circumstances of material importance, as tending to diminish the hazard from fire, to which cotton mills are so much exposed.

When Mr. Lee was examined by Mr. Brougham, in 1809, before a committee of the House of Commons, against the Gas Light and Coke Company's bill, his evidence was then equally favourable. He said, it gave no disagreeable smell; and when questioned as to the purity and goodness of the light, " I burn it," said he, " every night in my own house,

instead of thirty pairs of candles." He further added, that he found it perfectly wholesome, and that it was never complained of either in his own dwelling-house, or in the mill.

The President and Council of the Royal Society proved the high opinion which they entertained of the value and importance of Mr. Murdoch's communication on the employment of the gas from coal for the purpose of illumination, by adjudging to him Count Rumford's gold and silver medals.

To prove that gas is economically applicable upon a small as well as a large scale, reference might be made to Mr. Cook's statement in the Phil. Mag. Dec. 1808, which, with some other amusing particulars, is noticed in the Edinburgh Review, vol. XIII. page 477.

I have thought it right to state these particulars concerning the earliest trials of gas lights: and now, without adducing further evidence from those remote sources, shall proceed to information gained at the establishments lately instituted in the metropolis; and to that afforded by my own experiments. The apparatus, required for gas illumination, consists of retorts for the distillation of the coal, of condensers for the reception of the tar and ammoniacal liquor, of purifiers containing cream of lime, through which the gas passes, and is freed from carbonic acid and sulphuretted hydrogen, of gasometers or reservoirs with their main conduit pipes, and of the burners with their tubes and stop-cocks. Of the construction and expense of the whole of this apparatus, a tolerably correct estimate may be formed by consulting Mr. Accum's "Practical Treatise on Gas Light."

We are indebted to Dr. Henry, of Manchester, for some valuable researches, concerning the composition of the aeriform products of several varieties of coal. (Phil. Trans. 1808.) He has pointed out the various composition of the gas at different periods of the distillation, and has shewn the important influence of the circumstances under which the coal is distilled, upon the proportion of gas yielded, and its fitness for the purposes of illumination. This fact has lately attracted the notice of Mr. Clegg, the engineer of the Gas Light Company, who has founded upon it several ingenious improvements in the construction of the

retorts employed at the Westminster gas works. Coal in large heaps, and gradually heated, affords less gas and more water and tar, than when it is extended over a considerable surface, and suddenly brought to a red heat. It is also very advantageous to dry the coal before its introduction into the retort.

In a small gas apparatus, erected in the laboratory of the Royal Institution, we find that 4 lib. of good Newcastle coal, introduced into the retort previously heated red, in a shallow iron pan, may be made to afford a produce of from twenty to twenty-six cubic feet of gas, consisting of

8	Olefiant gas
72	Carburetted hydrogen
13	Carbonic oxide and hydrogen
4	Carbonic acid
3	Sulphuretted hydrogen
100	

The carbonic acid and sulphuretted hydrogen are separated by the lime in the purifiers.

The same quantity of coal introduced into the cold retort and gradually heated, afforded only twenty-two cubic feet of gas, consisting of

5	Olefiant gas
70	Carburetted hydrogen
18	Carbonic oxide and hydrogen
6	Carbonic acid
1	Sulphuretted hydrogen
100	

The specific gravity of the former gas, that of air being = 1000, was = 560, and of the latter = 555: the fitness of gases for the purposes of illumination is, generally speaking, directly as their specific gravity.

These experiments lead to the conclusion that a chaldron of good Wallsend Newcastle coals would afford from 17,000 to 20,000 cubical feet of gas, but the process of distillation as now carried on in the large establishments for lighting the metropolis seldom affords a larger average produce than 12,000 cubical feet. There can, however, be little doubt that

by improvements in the construction and management of the retorts, the highest of the above averages might be procured, and calculating upon this produce of gas, and upon the other substances yielded by the operation, we obtain a curious and striking result.

The average value of a chaldron of the best Newcastle coals is = 3*l.* The value of the products of its distillation is as follows:

	l.	*s.*	*d.*
$1\frac{1}{4}$ chaldron of coke, at 31*s.* - - - - -	1	18	9
12 gallons of tar, at 10*d.* - - - - -	0	10	0
18 gallons of ammoniacal liquor, at 6*d.* - -	0	9	0
20,000 cubic feet of gas, at 15*s.* per 1,000 cub. feet	15	0	0
	£17	17	9

From the value of products must of course be deducted the value of the common coal employed in the furnaces for heating the retorts, amounting to about five chaldrons for every five and twenty chaldrons submitted to distillation, and the expense incurred by wear and tear, with the wages of the labourers, and lastly, the interest upon capital. Mr. Murdoch's estimate, already quoted, will be found pretty accurate upon these heads.

The tar is frequently employed for the production of gas, either by mixing it with small coal in the retorts, or by passing it through a red hot tube. Every pound yields between seventeen and eighteen cubic feet, containing from fifteen to twenty per cent. of olefiant gas. When, therefore, it has been cleansed by lime, it burns with a very brilliant flame, and is a most improving addition to the common gas. Wigan and Cannell coal yield the best and largest proportion of gas for the purposes of illumination, but it is seldom it can be employed on account of its high price.

The burners, or tubes whence the gas issues for combustion, may be infinitely and tastefully varied. The varieties commonly employed are the bat's-wing burner, and the Argand burner. The former consists of a brass tube having a slit at its extremity about a quarter of an inch long and one-fortieth

of an inch wide. The latter is composed of two concentric brass tubes about two inches long, closed at bottom by a ring of brass, and at the top by one of steel perforated with sixteen or eighteen holes of one-thirtieth of an inch in diameter. The gas enters the cavity between the tubes, and issues from the circular row of apertures, where it is inflamed, and having a due supply of air within and without, burns very beautifully when a proper glass is placed over the burner. These burners, when very carefully regulated, consume about three cubical feet of gas per hour, and give light equal to that of six wax candles; but it is requisite, on account of carelessness and mismanagement, to allow four cubical feet to each burner per hour. The bat's-wing burner should not consume more than three cubic feet per hour.

At the three stations belonging to the chartered Gas-light Company, situated in Peter-street, Westminster, in Worship-street, and in Norton Falgate, twenty-five chaldrons of coals are carbonised daily, which actually yield 300,000 cubical feet of gas, equal to the supply of 75,000 Argand's lamps, each lamp giving the light of six wax-candles. But if the full proportion of gas were obtained, viz, 20,000 cubical feet from each chaldron of coals, then the produce should be 500,000 cubical feet, equal to the supply of 125,000 lamps of the same size, and the light afforded should equal that of 750,000 wax candles, instead of 450,000, which is the real produce.

At the City gas-works, in Dorset-street, Blackfriars-bridge, the daily consumption of coals, for distillation, amounts, at present, to three chaldrons, which afford gas for the supply of 1,500 lamps, so that the total consumption of coals daily in London, for the purpose of illumination, amounts to twenty-eight chaldrons, and the number of lights supplied to 76,500.

Besides the different varieties of coal, some of which, as has been hinted, are much preferable to others, and coal-tar, an useful gas may be procured from a variety of other substances; and in the laboratory of the Royal Institution we often feed the retort with waste paper, saw-dust, pieces of wood, &c. and consume the gas for a variety of purposes, where oil was formerly employed.

The following are the results of some experiments upon these subjects compared with the produce from coal.

1. The retort was charged with four pounds of coal. The quantity of gas amounted, after having passed the purifiers, to twenty cubic feet. The coke remaining in the retort weighed 2lb. 8.7oz.

The heating power of the gas flame was compared with that of a wax candle, by ascertaining the time required by each to raise two ounces of water, in a thin copper vessel, from 55°. to 212°. The flames were made as similar in dimensions as possible, and so placed that their points just touched the bottom of the vessel. The heating power of the candle being assumed as = 1. that of the coal gas flame was = 1.5.

2. Four pounds of the dried wood of the common willow yielded sixteen cubical feet of gas, and fourteen ounces of charcoal remained in the retort. The gas burned with a very pale blue flame, and was unfit for the purpose of illumination, and contained no olefiant gas.

3. Four pounds of the wood of the mountain ash afforded fifteen and a half cubical feet of gas, and thirteen ounces and a half of charcoal. The flame was very pale and blue.

4. Four pounds of white birch wood gave fourteen cubical feet of gas and twelve ounces of charcoal. The flame similar to 2 and 3.

5. Four pounds of hazle wood yielded thirteen cubical feet and a half of gas, and twelve and a half ounces of charcoal. Its heating power was = 1.2. It burned with a better flame than 2, 3, and 4, but the intensity was not sufficient for any useful purpose of illumination.

5. Four pounds of writing paper gave eighteen cubical feet of gas, and the remaining charcoal, which beautifully retained the form and texture of the paper, weighed eleven ounces and a half. The heating power of the gas was = 1.6. It burned with a flame nearly approaching in illuminating power to that of coal gas.

These experiments along with others which it is thought unnecessary to notice, prove that the gas from woods is not fit for the purposes of illumination, although as evolved

during the production of charcoal, it may conveniently be consumed in the laboratory as a source of heat.

Respecting the advantages of gas illumination in streets, open places, large manufactories, &c. there can but be one opinion; but its introduction into dwelling-houses involves some more important considerations. It may be urged in its favour, that the light is more equable, beautiful, and agreeable to the eye than that obtained from any other source; that superior cleanliness is attained, and the troublesome operations of filling and trimming oil lamps are superseded; that there is no danger from sparks and snuffs, as where candles are employed, and that by closing the main pipe of supply, a certain extinction of all the lights throughout the building is insured.

The following are the principal objections that have been adduced. When the gas escapes unburned, its smell is extremely disagreeable, and this may happen either from some fault in the pipes or burners, or from a stop-cock connected with a burner being accidentally left open. In the latter case the remedy is obvious, but in the former the escape of gas may prove very troublesome; but it may be guarded against by employing double pipes, by carrying them as much as possible upon the exterior of the house, and above all, by employing careful and good workmen in the construction of every part of the apparatus.

The idea of explosions, in rooms lighted by gas, has frequently occurred, but when the probability of such an event is calmly considered, much of the alarm that it has excited must vanish. For the formation of an explosive atmosphere a large quantity of gas must escape into an apartment which must be nearly air-tight; and in a room with an open chimney, and two or three doors and windows, it would scarcely be possible to obtain a dangerous mixture, though it might occur in a cellar or any other very small and close apartment. In a dwelling room the gas would announce itself by its smell, very long before any dangerous mixture could ensue, and the quantity of gas required would be very great. A room twelve feet square, or con-

taining 1728 cubical feet of atmospheric air, would require an addition of 247 cubical feet of coal gas to render its atmosphere explosive. If we suppose a large Argand's burner accidentally left open in this apartment, whence gas is flowing at the rate of 4 cubical feet per hour, it would require sixty-two hours for the above quantity of gas to flow into the room, which also must be *nearly* air tight; these circumstances can scarcely be supposed ever to occur; a very little attention to ventilation, which whenever gas is used should be strenuously insisted on, would remove all possibility of danger. But the best proof of the safety of gas illumination is, that notwithstanding the many thousand lamps nightly burning in London, six* accidents only are known to have occurred, and those of a very trifling and almost unimportant nature, though the pipes and lamps are generally badly and very carelessly managed. In matters of this kind, facts, and not arguments, must be looked to for evidence.

It was my intention to have concluded this paper with some observations on the construction of burners, and with an account of several important improvements lately made in the general apparatus by Mr. Clegg: the hope of rendering my account of these subjects more correct and perfect than is at present in my power, induces me to defer it till the appearance of the next number of this Journal.

Art. XI. *On an anomalous Case of chemical Affinity.* *By* Richard Phillips, *Esq.*

It is remarked by Sir H. Davy, (Elements of Chemical Philosophy, p. 103,) that "in many cases decompositions, that cannot be produced by single attractions, may be produced by double affinities. Thus the elements of sulphate of baryta, or the combination of sulphuric acid, and the earth called baryta, are so firmly united, that no alkali, nor earth, will

* Two of these arose from holes having been mischievously bored in the pipes of supply.

separate the acid from the baryta. Potassa, which has a very strong attraction for the acid, will not decompose it alone; but if potassa, combined with carbonic acid, be digested for some time with powdered sulphate of baryta, there is a double decomposition; and combinations of sulphuric acid and potassa, and carbonic acid and baryta, are formed."

Although this decomposition has been several times mentioned, yet it does not appear to me that the mode of its occurrence, or the precautions requisite to effect it, have been fully described. In mentioning it Dr. Henry observes (Elements of Experimental Chemistry, Vol. II. p. 331) " Sulphate of barytes is decomposed by carbonate of potash. Boil the powdered sulphate with a solution of twice or three times its weight of carbonate of potash. The carbonic acid will pass to the barytes and the sulphuric to the potash."

By referring to p. 228, vol. ii. of Klaproth's Analytical Essays, it will also appear that a very large proportion of carbonate of potash is required to effect the decomposition of sulphate of barytes; " three hundred grains of it were powdered, boiled with 600 grains of carbonate of potash and water, evaporated to dryness, again diffused in water, and a second time evaporated. Upon subsequent dilution with water, the earth was treated with muriatic acid, which dissolved it with effervescence, leaving a residue of 18 grains."

In this operation considerable care appears to have been taken to ensure the perfect action of the salts upon each other, and scarcely any doubt can be entertained of its having been accomplished; as 18 parts of sulphate of barytes escaped decomposition, it follows that 282 parts of it required 600 of carbonate of potash, for their conversion into carbonate; but the decomposition could not have been mutual in these proportions, for it will appear, by Dr. Wollaston's scale, that the carbonic acid and potash of only 165 of carbonate of potash are required to saturate the barytes and sulphuric acid of 282 of sulphate of barytes.

My attention was first drawn to the circumstances of the above stated double decomposition, by having learned from Dr. Babington, that sulphate of potash and carbonate of

barytes are also decomposed when the latter is boiled in a solution of the former. Having ascertained the practicability of both these cases of double decomposition, incompatible as they may appear, I made the following experiments for the purpose of ascertaining the circumstances under which they occur, and the extent to which they take place.

In order to obtain sulphate and carbonate of barytes in such a state of division as appeared most likely to favour their decomposition, by the exposure of numerous surfaces to the action of the carbonate and sulphate of potash, I prepared them by decomposing solutions of nitrate of barytes, by sulphate of soda and carbonate of ammonia; the precipitates being well washed with distilled water were dried. Crystallized sulphate of potash of known purity was employed, and I prepared carbonate of potash by decomposing the bicarbonate at a low red heat.

To ascertain the extent to which sulphate of barytes is decomposable, by ebullition in a solution of its equivalent of carbonate of potash, 100 parts of the former and 59 of the latter salt, were boiled during two hours in about four ounces of water; the solution was not evaporated to dryness, water being occasionally added to supply what was lost by evaporation. The insoluble residuum was washed with water till it was freed from the carbonate of potash undecomposed, and the sulphate of potash which had been formed; when diluted nitric acid was poured upon it, considerable effervescence ensued, and the portion undissolved by the acid being washed till the water gave no further indication of nitrate of barytes, weighed when dry 77 parts, consequently 23 of sulphate of barytes were decomposed by the carbonate potash, and converted into 19.5 of carbonate of barytes.

I now took quantities equivalent to those above used, of carbonate of barytes, and sulphate of potash, which, as will be seen by Dr. Wollaston's scale, are 85 of the former and 74 of the latter; they were boiled in water as in the experiment just described; having suffered the undissolved portion to subside, I examined the clear solution, it reddened turmeric paper strongly, effervesced with nitric acid, and gave a copious

red precipitate with solution of corrosive sublimate, the solution, therefore, evidently contained a considerable quantity of carbonate of potash, resulting from the mutual decomposition of the carbonate of barytes and sulphate of potash.

The residuum undissolved by the water, was washed with repeated affusions of it till it ceased to contain carbonate of potash; it was then, as in the former instance, treated with nitric acid in excess; this excited considerable effervescence, and I found that the nitric solution gave no precipitate with ammonia, but a copious one with its carbonate; and sulphate of soda occasioned a precipitate insoluble in muriatic acid. From these circumstances it is evident the whole of the carbonate of barytes was not converted into sulphate, and its actual quantity I found to be 67 parts, consequently 57 of carbonate of barytes were decomposed by the sulphate of potash.

In the first experiment 23 parts of sulphate of barytes were decomposed, consequently, as will appear by referring to the scale, the 100 parts of sulphate of barytes and 59 of carbonate of potash employed in it, become nearly as follow:

77. sulphate of barytes,
45.5 carbonate of potash,
17. sulphate of potash,
19.5 carbonate of barytes.

In the second experiment 57 of carbonate of barytes were converted into sulphate, consequently the 85 parts of carbonate of barytes and 74 of sulphate of potash gave about

67 sulphate of barytes,
39.5 carbonate of potash,
24.5 sulphate of potash,
28. carbonate of barytes.

The decompositions in both these cases are very considerable; but as the quantities of the salts which result from the action of the same proportions of similar acids and bases are not equal, it is probable that the decomposition was not in either case complete, on account of the mixtures not having been sufficiently digested and evaporated to dryness.

Supposing the insolubility of the sulphate of barytes in the

first experiment to have prevented the complete action of the carbonate of potash, we must also suppose the same cause to have prevented that of the sulphate of potash on the carbonate of barytes in the second experiment; and allowing this cause to have operated equally in both cases, the mean of the quantities stated will probably express the results which would have been obtained by carrying each experiment to its utmost limit.

On referring back to the quantities of salts used in each experiment, it will be seen by the scale that they consisted of acids and bases in nearly the following proportions:

34 parts of sulphuric acid,
19 ditto carbonic acid,
66 ditto barytes,
40 ditto potash;

and these combined so as to give the mean of the two experiments, will stand thus:

$$24.5\ S\ A + 47.5\ \ B = 72 \text{ sulphate of barytes.}$$
$$13.75\ C\ A + 28.75\ \ P = 42.5 \text{ carbonate of potash.}$$
$$9.5\ \ S\ A + 11.25\ P = 20.75 \text{ sulphate of potash.}$$
$$5.25\ C\ A + 18.50\ B = 23.75 \text{ carbonate of barytes.}$$

That these numbers express the quantities which would result from the perfect action of the salts upon each other, will appear probable by examining the results of Klaproth's experiment. He found that 600 parts of carbonate of potash decomposed 282 of sulphate of barytes, consequently 59, the quantity I employed, should decompose 27.6, which is within 4 of the stated average. We may then safely infer that not more than 72 out of 100 parts of sulphate of barytes can be decomposed by carbonate of potash, whilst the latter salt is exposed to the counteraction of the sulphate of potash formed by the decomposition of the 72 parts; and it would appear, that the power of the latter is sufficient to prevent the action of almost any quantity of carbonate of potash, however large, upon the smallest quantity of sulphate of barytes.

In Klaproth's experiment not more than 165 parts of carbonate of potash could have been decomposed by 282 of sulphate of barytes, and the sulphate of potash formed amounting

to 209 parts, by its power of reproducing sulphate of barytes, appears to have prevented the remaining 435 of carbonate of potash from decomposing 18 of sulphate of barytes, although it contained at least thirty times more carbonic acid than the barytes could have combined with.

To try how far these inferences would be strengthened by experiment, I boiled together, in water, for about two hours, 72 parts of sulphate of barytes, 42.5 of carbonate of potash, 20.75 of sulphate of potash, and 23.75 of carbonate of barytes. The result did not prove that the quantities are precisely those which prevent the reciprocal action, but they shewed that the error is not very considerable; I found an increase of about 3.75 of sulphate of barytes.

The result of this experiment is sufficient to shew, that the decomposition of sulphate of barytes by carbonate of potash is prevented from taking place by the power which sulphate of potash and carbonate of barytes possess of reproducing it; and *vice-versa,* that the power of sulphate of potash and carbonate of barytes of effecting mutual decomposition is equally destroyed from the corresponding power of reproduction belonging to sulphate of barytes and carbonate of potash.

I do not offer any explanation of this anomalous case; it is merely expressing a fact to state in language slightly altered from Berthollet, that there takes place a partition of bases between the acids whose action is opposed: it is, however, evident, that the case is not one of those which he has attributed to the action of *mass;* for, independently of other considerations, it appears from Klaproth's experiment, that a large portion of carbonate of potash is powerless in decomposing a small quantity of sulphate of barytes.

Some of the experiments on which Berthollet founded the doctrine of the action of *mass,* have been explained by shewing the formation of supersalts when a weaker acid has been supposed to divide a base with a stronger; and one of the cases in which a base possessing a weaker affinity for an acid, has been supposed to divide it with one whose affinity for it is stronger, has been shewn, by Sir H. Davy, to be fallacious; as he has stated, in contradiction to Berthollet, that potash

does not decompose sulphate of barytes when the experiment is properly conducted.

Art. XII. *On the effects of a Paralytic Stroke upon the Powers of Adjustment of the Eyes to near Distances. By Sir* Everard Home, *Bart. V.P.R.S. M.R.I. &c.*

There are no facts upon record which I am acquainted with that relate to the effects of injuries to the brain on the powers of adjustment of the eye. I have, therefore, brought forward the following with a view to draw the attention of physiologists to this enquiry; and the numerous cases of paralytic affections which occur, afford ample opportunity of making observations on this subject.

A gentleman had an apoplectic fit in the fifty-third year of his age. He remained in a comatose state for four days. In three weeks he could distinguish his attendants so as to know them. He was completely paralytic on the right side, the eye-lids of the right eye closed, the right corner of the mouth drawn up. He lost his speech, and did not see with the left eye, although its appearance was natural. His hearing and taste good. In three months he was able to walk for two hours without resting. His face had recovered its natural appearance, except that the upper eye-lid of the right eye was not fully open. Near objects were indistinct, and he was unable to read; but a pin upon the carpet at the distance of ten feet he saw, and pointed to it for some time before any of his attendants could distinguish it, although they wanted one for his use. This led him to enquire of his surgeon, Mr. Cave, who is a pupil of mine, the reason of his not being able to read the newspaper, when he saw so small an object as a pin at that distance. Mr. Cave mentioned the circumstance to me; I stated that this patient had lost the power of adjusting his eyes to near distances, and begged of him to try whether this was the case with one or both eyes.

Experiments of this kind were made on each eye separately, placing the newspaper before one, and binding up the other; the paper was brought close, then further off, but the outlines of the print were indistinct whichever eye was employed.

ART. XIII. *Review of a Work entitled,* "*Essai d'un Cours élémentaire et général des Sciences physiques. Par* F. S. BEUDANT, *Sous-Directeur du Cabinet de Minéralogie du Roi, Professeur de Physique dans l'Université Royale, Membre ou Correspondant de diverses Sociétés savantes.*"

Partie Physique.

To the natural philosopher, who, in the pursuit of a favourite science, adds a new fact to the general stock of knowledge; or, more happy still, developes from experimental research some hitherto-concealed law of the operations of nature, the general suffrage of the learned justly ascribes the palm of successful exertion: but no less deserving is the man who, with less aspiring and striking pretensions, smooths the paths of science by a judicious and well-digested arrangement of her scattered elements and principles. The further we advance into the boundless regions of research, and the more we accumulate facts and conclusions, the more we stand in need of order and connected disposition, the *memoria technica* of cultivated minds. We are happy to have it in our power, upon our first instalment in the critic's chair, to direct the attention of our readers to the exemplification of this merit, by introducing to their notice a systematic course of the physical sciences, in the essay of M. Beudant now before us. Modestly professing no higher purpose than that of preparing young men, on their first entry into the world, to choose a profession, and of developing certain general and fundamental principles which may serve in future to direct them in the selection of agreeable and useful occupations, the author has presented us with a lucid and novel exposition of the natural alliance of the different branches of physics, discriminating the various points of connection

between the sciences, as well as the distinctions by which they are divided. Their first principles are stated with clearness and precision, and illustrations of the subject are selected from phenomena which are commonly occurring, a practice which we cannot too highly commend; coinciding as we do most fully in the remark, that nothing is more likely to communicate a habit of observation, than a perpetual endeavour to refer to their true causes effects which are continually passing before us. We shall endeavour to sketch a rapid outline of a plan, which we consider at once novel, elegant, and useful.

Our author commences with a definition of space considered abstractedly from matter. The measure of limited or relative space, as contradistinguished to infinite or absolute space, belongs to the mathematical sciences, and is the object of geometry, trigonometry, &c. To the mathematics likewise appertains the consideration of ideal quantity, considered apart from the sensible qualities of bodies, as in the problems of arithmetic and algebra.

Matter is defined a limited quantity, endued with properties perceptible to the senses. It is generally distinguished from space by impenetrability, or the property which a body possesses of excluding all others from the place it occupies. The contemplation of the properties of matter is the province of the physical sciences.

Necessarily consequent to the idea of quantity, is that of divisibility. Geometric division may be continued *ad infinitum*; we have yet to learn the limits of mechanical division.

Matter is divided into solids, liquids, aeriform fluids and incoercible fluids. The characters of the three first are distinct and well defined, and experiments have rendered it probable that they are mere results of modified temperature. The latter are four in number, and their existence has been rather imagined than proved, to account for the phenomena of heat, light, electricity, and magnetism.

Bodies, thus divided, may be considered under two distinct points of view, *viz.* in a state of rest, and in a state of motion. Their tendency to continue in either of these relative states,

when uninfluenced by any exterior agent, is termed the *inertia* of matter.

Power is required to overcome the resistance of bodies. The calculation of powers, their duration, and intensity, is the province of mechanics. Statics, the first branch of the science, treats of the ratios of different powers, their quantity, and duration. Dynamics, the second branch, seeks the manner of a body's motion, when acted upon by powers which do not mutually balance each other. To the first pertains the calculation of the results of powers applied in different manners and upon given points, and the conditions of equilibrium between opposing powers; to the second, the laws of uniform motion, regularly accelerated and retarded motions, curvilinear motion, and centrifugal force.

There is one general power which acts upon all matter, namely, the power of gravitation. The earth is demonstrated to be a spheroid, isolated in space: what is it preserves its component parts from being dissipated in boundless regions? and why do bodies, which are elevated above its surface, fall, when unsupported, towards its centre?

We can find no other cause for this strange phenomenon, says our author, than the will of Supreme Wisdom: but every thing occurs as if the centre of the terrestial globe were endued with an attractive power, which drew towards it al surrounding bodies; hence, without seeking to penetrate further, it is agreed to designate the phenomena by the names of attraction, gravitation, or gravity; and from this, as from a fixed point, we set out in our explanations and predictions of a multitude of other phenomena. The prescience which theory thus enables us to attain, accords so well with what really happens, that it would seem as if the Deity, to impress us with an idea of his immensity, had unveiled the secret of the laws by which he rules the universe.

The weight of a body is the pressure which it exerts upon any obstacle which opposes the efficiency of this power: under the same bulk, different bodies exert different degrees of pressure. This difference compared, is termed specific gravity.

Under the influence of gravity, bodies acquire a regularly

accelerated motion: this is modified by opposing powers, as in the compound action of the inclined plane, the curvilinear motion of projectiles, and the oscillation of the pendulum

But gravitation is not confined to terrestial objects: universal nature is obedient to its laws. It was the genius of a Newton that first conceived that the elliptical motion of the moon around the earth was the result of its projectile force, combined with the earth's attraction. From the data of astronomical observations, combined with experiment, he calculated the laws of this compound movement; and with a sublimity of conception, which carries human reason to the utmost confines of its widest stretch, he applied the rule to the planetary system, and demonstrated the harmonious motion of worlds and their attending satellites around their central sun, obedient to the simple laws of gravitation.

The attraction of cohesion is the next most general power which acts upon matter. It differs from gravity, in that it acts at infinitely small distances; so that if the smallest interval is perceptible to the eye between the attracting bodies, it ceases to be efficient. Its force is exerted upon the homogeneous particles of substances.

The attraction of composition, the particular consideration of which belongs to chemistry, is the affinity which exists between the heterogeneous particles of a compound body: like the former, it acts only at inappreciable distances. Thus in a mass of salt, alum, &c. we distinguish two different causes which concur in their formation; the attraction of composition unites the simple molecules of different species to form compound particles, which are termed integrant particles; and the attraction of cohesion aggregates the integrant particles into one consistent mass.

The figures of solids are either regular or irregular. The former are called crystals, and consist of polyhedrons terminated by plain, regular facets. The cause of these differences is to be sought in the varying circumstances which attend the act of aggregation. The relations of the different figures, the measurement of their angles, and the laws of their formation are the pursuits of crystallography.

There are three general properties which are common to all solids—porosity, impenetrability, and divisibility.

In France, the greater part of natural philosophers imagine that there is in bodies more of *vacuum* than *plenum*; and indeed this must be admitted, if we assimilate molecular attraction to gravitation, which acts in inverse ratio to the squares of the distances of the attracting bodies. The spaces, by which the particles of bodies are separated, are denominated pores. The proofs of this porosity are derived from the imbibition of liquids by solids, and the permeability even of the denser substances of the metals.

It is scarcely necessary to enter into the proofs of the impenetrability of solids, for it is self-evident, that if a body occupies a space, it must of necessity exclude all other bodies. Division may be carried on in them to an inconceivable extent, but we know not whether, like geometric divisibility, it may be pursued indefinitely.

The properties of ductility, extensibility, flexibility, compressibility, elasticity, hardness, and tenacity, are common in greater or less degrees to different kinds of solids. The calculations of their results and modifications form separate sections under each of the above denominations.

To resolve the Problems of Dynamics with respect to solids in motion, it is necessary to take into consideration, the manner in which the active powers are modified by the mutual connection which exists between their various points of application, the peculiar properties of the bodies themselves, and of the surrounding bodies.

The rotatory motion of a solid upon its axis is affected by its shape, but not by any other of its physical properties.

The result of the force with which two solids meet is different, for ductile bodies and for elastic bodies, and their shock may be divided into the centric and the excentric. The relative masses and velocities of the concurring bodies enter into the calculation of the resulting effect.

Motion is modified by friction. It is of two kinds: the first arises when a body slides upon another, and always presents to it the same points of contact: the second, when a

body rolls upon a plane and presents successively different points of its surface. In the latter case, the amount of its effects is much less than in the former; for the rotatory motion disengages the asperities of the two bodies from one another as the teeth of wheels rise from mutual contact. The due appreciation of this power is of the utmost consequence in mechanical combinations.

The vibratory motion of bodies of a perfectly elastic nature when regular, and of a certain velocity, produces sound, and conversely whenever a body emits sound, all its particles vibrate more or less rapidly in proportion to its intensity. The laws of these phenomena are the principles of Acoustics. Every one distinguishes a difference between sound and noise. Sound is the result of the continued vibration of a body whose oscillations are isochronous. When the vibration on the contrary terminates abruptly, or is continued irregularly, the sensation upon the ear is noise. There are three kinds of vibrations, the transverse, the longitudinal, and the rotatory, and their effects have been studied with success as produced from chords, as in the piano forte, or from metallic rods, as in the tuning fork. The laws of the vibrations of plates, or extended membranes are not so well understood. Vibratory motion is communicated from sonorous solids to all bodies with which they are in immediate contact, or with which they are in any manner of communication. The intensity and velocity with which it is transmitted, varies with the nature of the medium. The comparison of different sounds, is the science of music. When a body in a given time makes double the number of vibrations of another body, the emitted sounds are said to be octaves to one another. The muical scale is the series of successive sounds which are included in an octave.

The form of *liquids* is that of the vessels in which they are contained, with a plain horizontal surface, or rather with a convex surface which is the segment of a sphere concentric with the earth. Very minute portions however, assume a globular form, which is owing to the attraction of cohesion acting in all directions equally upon particles which are freely

moveable amongst themselves. The greater or less degree of fluidity modifies this action, as also the attraction of the body on which they rest, and the influence of gravity.

The form of the ultimate particles of liquids is held by some to be spherical from the facility with which they move amongst themselves, while the reciprocal conversion of solids into liquids, and liquids into solids, is urged by others as a strong argument of the similarity of both.

Porosity and impenetrability are properties which appertain to liquids in common with other matter. They are also elastic, but not compressible. The adhesion of liquids to solids, the wetting of the latter by the former, hygrometric action, and certain actions of liquids upon one another, as the expansion of oil upon water, are probably joint modifications of cohesion and affinity.

The essential property of liquid bodies, is the perfect mobility of their particles. This character, joined to impenetrability, leads to the principle of equality of pressure in all directions, which is the basis of Hydrostatics.

A solid body which exactly fills a vessel in which it is placed from the mutual connection of its different parts, presses only in the direction of gravity upon the bottom of that vessel; but a liquid in the same situation exercises likewise a pressure perpendicular to the former. Under particular circumstances it also presses from below upwards; as when it is confined in a vessel which is closed at the top, a force applied in any direction acts upon the upper surface as well as upon the sides and bottom. The laws by which these various pressures are regulated and apportioned, are developed by calculation.

When a solid body is plunged into a liquid of less specific gravity than itself, it displaces a portion which is equal to its own bulk, and it loses a part of its weight equal to the weight of the liquid displaced. Upon this principle is founded a common method of determining specific gravities.

If a solid body be placed upon the surface of a liquid of greater specific gravity than itself, it displaces a volume which is equal to itself in weight. Upon this principle is founded

the practice of aerometry, or the measurement of the density of liquids by floating bodies.

Capillary attraction, or the spontaneous rise and fall of liquids in small tubes, is dependant upon a result of molecular attraction which has been determined by M. Laplace. He has demonstrated that a body terminated by a curved surface, exerts a different degree of action upon the particles of its surface, to what it does when bounded by a plain surface. The tendency of the attraction is always towards the interior of the body, but this tendency is greater when its surface is convex and less when concave. Now when a solid body is immersed in a liquid, if the mutual attraction between the particles of the latter be less than that between the solid and liquid, the liquid will rise above its level in immediate contact with the solid, forming a concave curve upon its surface. If two bodies be thus immersed so nearly in contact that their respective curves join each other, the whole body of the liquid will rise between them, for its molecular attraction is less under the concave surface than it is in any part of the adjoining plain surface. If we substitute a tube for the two bodies, the same effect will obviously result in a greater degree between its two surfaces, and the effect will be in proportion to the smallness of the bore, that is to say, in proportion to the increasing concavity of the inclosed surface. This result is demonstrated by the immersion of a small tube in a glass of water. If on the contrary, the tube be plunged into quicksilver, the attraction of the particles of the latter are greater for one another than they are for the glass, a convex surface is the result, and the molecular attraction under these circumstances being greater than under the adjoining plain surface, the liquid sinks below its level.

Liquids in motion present many important and curious considerations. In running out of a vessel by a small aperture, the whole mass is in motion. The effect may be observed by mixing light particles of any kind with a transparent liquid If the aperture be in the bottom, they will be seen to descend vertically to within a short distance of it, when they will all

rush towards it with a direction more or less oblique. The same thing happens if the aperture be in the side of the vessel, and not only those particles which are situated above, but those also which are below tend to the same point. While the vessel is becoming empty, the surface of the liquid remains horizontal and falls gradually to within a few inches of the bottom, when a funnel-shaped cavity is formed, whose point is immediately over the centre of the orifice, and whose concavity gradually enlarges as the liquid decreases. If the orifice be in the side, this does not occur, but the level of the liquid falls towards that side. The stream which runs from the vessel contracts as it issues from the orifice, and goes on decreasing to about the distance of the semi-diameter of the aperture The cause of this phenomenon is to be found in the curves which the particles in the interior describe; which, converging together by their convex sides, cannot be reduced to parallel lines, till they reach a certain distance from their nearest point of junction. If the column of liquid falls, it goes on decreasing, owing to the accelerated motion which it acquires; on the contrary, in a rising jet, the column swells as it increases in height, owing to the gradual retardation of its velocity.

The motions of liquids, through an aperture in the thin sides of a vessel, through additional pipes, and their pressure upon the sides of those pipes, their passage by open canals, and the erosive action which they exercise upon their sides and bottoms, are all matters of curious hydraulic computations.

In considering the percussion of liquids, and in estimating its force, the size and velocity of the current, and the form and size of the body upon which it acts, must be included in the calculation. The resistance of liquids is proportionate to their density.

If a solid fall perpendicularly upon the surface of a liquid, it penetrates the mass and loses part of its velocity, but suffers no deviation from its course; but if it fall obliquely upon its surface, it is turned from its original direction and is refracted from a line perpendicular to the point of its first immersion.

The angle of refraction is proportionate to the density of the liquid. As the angle of refraction is necessarily less than the angle of incidence, it follows that the refracted motion of a body will become horizontal, or coincident with the surface of the liquid before the original motion. If the original motion be brought nearer to the horizontal direction than this point, the body will be reflected the same as if it had encountered a solid: that is to say, making the angle of reflection equal to the angle of incidence.

Liquids are capable of an oscillatory motion, upon which is founded the theory of waves, and of a vibratory motion, as may be seen by the agitation of water in a glass from which sound is elicited.

The figure of aeriform fluids is that of the vessels in which they are contained, but differing from liquids in as much as their surfaces never of themselves assume the horizontal direction.

The characters of porosity and impenetrability extend to this class of bodies. Their compressibility is perfect, and they can be made by force to contract into an infinitely less space than that which they naturally occupy.

Their elasticity results from change of volume, and not from change of form or the oscillation of their component molecules. Their weight, like that of solids and liquids, may be determined by the balance.

Every aeriform fluid inclosed in a vessel, by virtue of its elasticity, is perpetually making an effort to dilate itself; in consequence of which, it presses outwards upon the sides in proportion to its density and temperature. Setting aside all other considerations, this pressure is equal upon every part: combined with the effect of weight, it varies with the height of the column. The modification thus produced, taking compressibility into the account, is such, that if we suppose the height divided into different horizontal layers, the last layer which supports the pressure of all the others, will be compressed to a certain degree; and the others, having successively less and less weight incumbent on them, will be less

compressed and less elastic. This effect is null with respect to the small vessels which we are capable of using in our experiments, but is very sensible in that vast reservoir of elastic fluid, the atmosphere. The pressure of the air is not commonly sensible upon ourselves or upon surrounding objects, on account of its acting equally upon all sides; but if the equilibrium be disturbed, and the fluid be removed from any part of a body while the rest is exposed to its action, the effect is immediately manifest. It is to the application of this principle that we owe the barometer, the syphon, and different species of pumps. Bodies float in elastic fluids in the same manner that others swim in liquids. Upon this property is founded the art of aerostation.

The chief and most general cause of the motion of aeriform bodies is change of temperature. The effects of their motion and percussion are modified by their density and velocity, and by the surface of the body upon which they strike.

The air is capable of a vibrating motion by which sound is produced, as in wind instruments. This motion is also communicated to it by other vibrating bodies, and it is thus that sound is commonly transmitted. As it receives the impulse, so likewise is it capable of communicating it; and the vibrations of a chord may thus be impressed upon the air, and by it conducted to another chord.

The undulations of the air resemble, in many instances, the waves of liquids. When they encounter any obstacles, like them they are reflected, and thus we account for echo.

The phenomena of heat, light, electricity, and magnetism have been explained upon the supposition of Descartes, of an eminently subtile fluid, which fills all space, and which he has denominated ether. Various vibrations and vortices in such a medium produce the effects which are distinguished as above. The idea, however, of an unconfinable fluid peculiar to each series of these effects, is now generally adopted; and though, from their inappreciable gravity, their existence is by no means proved, yet from their propagation through

vacuum, and their reflection from other bodies according to the known laws of matter, it is rendered highly probable.

Caloric, or the matter of heat, penetrates all bodies with great facility. Its rays are reflected from the surface of polished bodies at an angle equal to the angle of incidence; it is refracted in passing through diaphanous bodies, and absorbed by bodies with a rough surface. Equilibrium of temperature, when disturbed, is restored by the conducting power of other bodies, or by the self-radiation of caloric. The conducting power of bodies varies very considerably, and radiation is also affected by the surfaces from which it emanates. Heat distributes itself uniformly in homogeneous, but not in heterogeneous bodies, different substances having different capacities for it. The comparative quantity which each contains is called its specific heat.

Matter absorbs caloric during its dilatation, and emits it during its condensation. Conversely it dilates from accession of temperature and contracts from its decrease. This property in bodies which expand equably, is employed for thermometers and pyrometers.

The expansive power of vapour, united with its facility of condensation, is most usefully and scientifically employed in the steam engine.

Bodies assume the solid, the liquid, and the aëriform state, according to the relation which subsists between the attraction of cohesion and the repulsion of caloric. The heat which combines with a solid to render it liquid or aëriform, is no longer sensible, but becomes latent: on the contrary, in passing from the rarer to the denser state, it is again emitted, and becomes evident by increase of temperature.

The consideration of the properties of light is divided into three branches: optics, which treat of direct light; dioptics, of light in its passage through diaphanous media, and catoptrics, of reflected light.

Light is propagated in direct lines and in diverging rays. The velocity of its motion is immense: and it has been calculated that it passes from the sun to the earth in the short

period of eight minutes. Its intensity, setting aside the influence of any medium through which it passes, is in inverse ratio to the square of the distance of the emitting body. It is both attracted and repelled under different circumstances, by various forms of matter.

The law of refraction in light differs from that of a solid passing from a rarer to a denser medium, which turns it from its direction by the resistance which it opposes, and seems to be the result of an attractive power, by virtue of which the luminous ray is drawn nearer to the perpendicular of the point of immersion. When a point of light falls perpendicularly upon the surface of a diaphanous body different from that which it originally traversed, it continues its course without experiencing any deviation; but if it pass obliquely, it suffers a refraction towards the perpendicular in the more refractive body, and from it in the less refractive. Bodies vary very considerably in the degree of this power which they exert upon light. In general the denser media refract more strongly than the rarer: but their influence depends likewise upon chemical composition, and combustible bodies especially possess it in a high degree. Refraction is variously modified by the form of the surface of the refracting substance. The laws of vision and the construction of the eye have been successfully investigated in this department of physical science.

When light falls upon a body of a sombre hue it is partly absorbed; but when it falls upon a white substance, or a polished surface, it is more or less completely reflected. The angle of reflection is equal to the angle of incidence. The reflection of light is variously modified by the forms of the surfaces from whence it arises, as from convex, concave, cylindric, and other mirrors.

Some diaphanous bodies possess the property of dividing the ray of light which traverses them into two points, one of which follows the law of ordinary refraction, and the other a particular law, which was discovered by Huyghens.

Transparent carbonate of lime exerts this action in a high degree. The angle of ordinary refraction always bears a ratio to the angle of incidence: the angle of extraordinary

refraction depends upon the direction of the ray with regard to the axis of refraction (a line which coincides with the axis of crystallization in carbonate of lime.) When the ray is directed in a perpendicular or parallel direction to this axis, there is no extraordinary refraction; but when it is inclined to it, the refraction is greater or less, according to the angle of inclination.

Light thus refracted is endued with some particular properties. When it is again made to pass through a rhomboid of double refracting spar, whose axis is parallel to that of the original crystal, it passes on without suffering any division: but if the second rhomboid be turned slowly round while the first remains stationary, each of the pencils begins to separate into two: and when the eighth part of a revolution is completed, they arrive at their furthest point of division: when the fourth part of a revolution is effected, the pencil refracted in the ordinary way by the first crystal is wholly refracted in the extraordinary way by the second; and that refracted in the extraordinary way by the first, is ordinarily refracted by the second. The same phenomena occur at every quadrant of the turn. Light which possesses these properties is called polarised light, and its peculiarities are supposed to depend upon a peculiar relative arrangement of its particles, in which their axes and similar faces are all similarly disposed.

This modification is not conferred solely by refraction. Malus has discovered, that light reflected from various substances at certain determinate angles for each, is endued with the same properties. This angle in glass is 35°.

Polarised light is affected in a particular manner by reflecting surfaces. When a second reflecting plane is placed parallel to the first, the ray is wholly reflected; but when the new plane is perpendicular to the original one, it is, on the contrary, entirely refracted. The intermediate degrees are characterised by intermediate quantities of absorption and reflection. Polàrization may also be conferred by ordinary refraction. Thus, in passing through glass, light is polarized in part; and if we transmit it through a series of parallel glasses, part of the molecules which have escaped the operation of the first are

detained by the second, and another portion by the third: so that at last, if the number be sufficient, a completely polarized ray is obtained.

There is another modification of light which is amongst the recent discoveries of the present day. It is supposed to arise from an oscillation of the particles around their centres of gravity. If a ray of polarized light be made to pass through a thin leaf of mica, or selenite, and then analysed by a rhomboid of double refracting spar, it no longer passes through single, but two images are produced, of different colours, which are complementary to each other, that is to say, which produce white light by their mixture. The ray which falls upon the mica penetrates entire to a small depth, without the axes of its particles experiencing any deviation from their position; but at a certain depth, which is different for the different coloured particles, they begin to oscillate like the balance of a watch. These oscillations are confined to the same limits, but vary in velocity. The violet particles turn more rapidly than the blue, they more rapidly than the green, and so on to the red, which are the slowest of all. From this inequality it happens, that for every thickness of the leaf, different colours are found at the two limits of oscillation; and from hence arise the two differently coloured pencils, which are observed in analysing the transmitted light.

Various experiments prove, that the light of the sun is composed of particles of different colours which are differently refrangible and reflexible. The separation of these particles is termed the dispersion of light, and upon it depends the beautiful Newtonian theory of colours.

The principal means of producing electrical energy, are friction, contact, and heat. There are two hypotheses to account for its phenomena. The hypothesis of Franklin supposes a particular fluid inherent in all matter, but disposed in various quantities in different bodies, according to their capacity. As long as an equilibrium is maintained in a particular system of bodies its existence is not manifest: but directly that any cause disturbs the balance, phenomena are produced, which

are owing to a tendency to its re-establishment. This beautiful and simple theory is generally established in this country; but in France we are told, that the following explanation of Symmer has been substituted. All nature is embued with a particular fluid, which is denominated the natural fluid, and which is composed of two others, the vitreous and the resinous. It is these two component parts which, when in a state of freedom, produce electrical effects by their tendency to re-union.

M. Beudant acknowledges the greater simplicity, and nearer accordance with facts, of the former theory; but nevertheless explains all the phenomena upon the latter: for what to us appears the very insufficient reason of its general prevalence. It would be useless in us to follow him in details, upon the principle of *deteriora sequor*, unsupported even by the excuse of universal error.

The same observations and objections apply to the explanation of magnetical effects by an Austral and Boreal fluid, forming by their union a neutral natural fluid.

But a still more extraordinary deference to received opinion is manifested in this concluding section of the work, and one that ill-accords with that close induction from facts which we expect in the physical sciences, and which our author has admirably illustrated in the judicious selections which he has made.

It is an established fact, says he, that magnetism acts upon the animal œconomy; it eases the tooth ache; it cures the megrims; and sometimes excites a flow of blood to the part to which it is applied; it produces, *in general*, a sufficiently decided action upon nervous disorders.

It grieves us to find the laws of gravitation, and the fancied alleviations of a fanciful disease, placed upon the same footing in a book of Science.

We look forward with pleasure to the completion of this useful work in the promised publication of the treatises on Chemistry and Natural History.

ART. XIV. *Some Account of the Life and Writings of Hedwig.* *By* M. DELEUZE, *(from the 2d. vol. of the Annales du Museum National d'Histoire naturelle.)*

MANY of the foreign philosophical transactions contain biographical memoirs respecting those who, by their writings or discoveries, have contributed to the improvement of science. It is intended that a portion of each volume of the present Journal should be set apart for biographical notices of this sort; at present, we must be content to collect from the works of our neighbours that which appears most interesting, trusting before long we shall be enabled to be more independent, and give to the public the lives of our own countrymen. Hitherto little has been done in England of this kind.

The celebrity gained by those who undertake to treat of the grand phenomena of nature, and who give to the world general views founded on some particular theory, is usually of no very long duration: time robs them of much of their fame, and posterity judges solely by the facts which they have contributed to science. Those, on the contrary, who attach themselves to some particular branch of science, and thereby become intimately acquainted with all its details; and who, by exact observations and nice analogies, are enabled to discover errors and furnish data for general conclusions, obtain by slower degrees a more lasting and increasing reputation.

Amongst those indefatigable observers of nature who have registered a vast number of facts, which have thrown considerable light on natural history, Hedwig is one who has many claims to the gratitude of botanists.

It is intended in the following pages to give a short account of this person, to point out his principal discoveries, to distinguish between such of his opinions as are proved, and such as remain doubtful, and to point out the facts relating to vegetable economy which were first noticed by him, and which have been since more firmly established.

John Hedwig was born at Cronstadt, in Transylvania, on the 8th of October, 1730. He was the son of one of the

magistrates of that town by Agnes Galles. His passion for botany shewed itself from his earliest youth; and as he studied at the college in his native town, the hours which were usually devoted by his fellow-students to sport and recreation, were entirely employed by him in wandering about the neighbouring fields collecting wild plants, which he transplanted into his father's garden. Those species which were conspicuous for their beauty, did not find any particular favour with Hedwig: who, anxious to collect together the greatest number of specimens that the garden would hold, attached himself in particular to the smaller species: and such a lasting impression did this amusement of his early years make on his mind, that having received late in life an herbarium of the plants about Cronstadt, and some seeds, he was enabled from memory to point out all such as were wanting, and to give directions as to the particular spots where each would be found.

Having lost his father in 1747, he went to Presburgh for the purpose of continuing his studies, where he remained for two years; and having passed through the different classes, intending to follow the profession of medicine, he went to Zittau to attend the lectures of Gerlach; and at the end of three years he entered himself at the university of Leipsic, and attended the lectures on medicine, philosophy, and mathematics. Amongst his instructors were Kæstner, E. Hebenstreit, Ludwig, and Bohmer.

His ardour for study and the gentleness of his disposition gained at once the esteem of his preceptors and of his fellow-students; and Ludwig, in a public discourse, bestowed the highest praise on his zeal, talents, and acquirements, and acknowledged the service he had done to the university in arranging the public garden and library, and enriching its cabinet with many valuable anatomical preparations.

Bose, the professor of botany, placed so much confidence in Hedwig, that he took him into his house, gave him the care of his garden, and for three years allowed him to attend for him at the hospital. This assistance was of great service to Hedwig; the little money he received from his family not sufficing to support him at the university. His studies being completed,

his merit was sufficiently known at Leipsic to have ensured his early success; and until he got practice, he might have obtained the means of existence by remaining with Bose. But all the wishes of his heart were centered in his native town, and he was incapable of deriving enjoyment from exertions which did not tend to the immediate benefit of his countrymen. He returned therefore to Cronstadt; and his vexation and disappointment may be well imagined, when, upon applying to the magistrates for license to practise as a physician, he found that this was denied him, by reason of a law which forbade all physicians to practise in Transylvania, who had not been members of the university of Vienna.

Compelled, therefore, to seek some other town, he hesitated for some time whether to follow medicine, or become a candidate for a professor's chair at Leipsic. The latter was best suited to his talents; but it was necessary to obtain it according to the statutes of the university, that he should have taken his degree first as a master of arts, afterwards as doctor of physic, and then as member of the faculty. These formalities required both time and money, and such a course was consequently rendered difficult by Hedwig's situation; he then, by the advice of his friend Bose, determined to commence practice as a physician in a small town in Saxony, and consequently presented his dissertation 'sur l'emploi des émetiques dans les fièvres aigues,' and was admitted doctor in medicine, without having taken his degree of master of arts. His friend Alors Grundig residing at Chemnitz, he was induced to make choice of that town, to which he returned after having married Miss Sophia Teller.

Enthusiastically fond of botany, he endeavoured so to gratify his partiality for this science, that it might not interfere with his professional avocations. He went forth into the fields every morning before sun-rise, and herbarized for several hours; on his return he devoted his day to visiting his patients, and to the consideration of their cases, and his evenings were spent in the examination of the plants he had collected in the morning, and to the cultivation of those in his garden, observing minutely every part tending to throw light on the physiology

of vegetation. As those plants whose characters were remarkable, were well understood, he attached himself more especially to the gramineous tribes, and those of the order *cryptogamia;* but having neither books nor the means of procuring them, his pursuits were frequently interrupted by difficulties which it was impossible to overcome without them; he wrote to the celebrated Schieber, then about to publish the "Flora" of Leipsic, for information on certain points. Schieber, pleased with his observations, commenced a correspondence with him, and furnished him with the means of study, sent him books, and gave him first a simple microscope, and afterwards a compound one made by Rienthaler the optician.

The joy, and the gratitude on receiving such a treasure may be imagined, and Schieber was himself fully recompensed, when on going to Chemnitz some years afterwards on a visit to his friend, he was shewn by Hedwig the sexual organs of the mosses which had been discovered by him by means of his friend's microscope.

Hedwig made some improvements in the microscope of Rienthaler, though a very good one, whereby it was rendered much more convenient; and as by the help of it he each day made some new discovery, that he might preserve the recollection of them, and be enabled to communicate them to others, contrary to the received opinion, that nothing is acquired at an advanced period of life, which was not in some degree cultivated in youth, he taught himself, at the age of forty, to draw. On examining the mosses, Hedwig soon perceived that they were subject to the same laws as other plants, but that *Linnæus* had been mistaken respecting their organs of fructification; he saw that the urn-like vessels on a pedicle, which the author of the Sexual System had taken for anthers, were true capsules, and contained seed, and that the little oblong bodies inserted at the axillæ of the leaves were the anthers. This, however, was only an opinion formed from analogy; but on the 17th of January 1774, having seen an anther of the *Coryum pulveratum* open and eject the pollen, his discovery was confirmed, and he set about establishing it by experiments on all the different species he could procure; this

became his principal occupation ; he discovered in all, the same organs ; and having sowed the seeds of many different species, succeeded in raising them, and was enabled distinctly to perceive their cotyledons.

These series of observations, and the new discoveries which he daily made, and which so fully confirmed the truth of his speculations, were a source of infinite pleasure to Hedwig, and rendered his life completely happy, surrounded by his family whom he loved, contented with the esteem of a few friends, and satisfied with himself from a consciousness, that he was of service to his fellow citizens by his attendance on the sick, and more especially of the poorer classes. He neither sought to augment his fortune nor to acquire fame; a life of simplicity and frugality, aided by domestic economy, prevented his ever feeling the want of wealth; the study and the admiration of nature and her works, alone occupied his mind; and from these sources he derived pleasures, the more valuable because they were unalloyed with dispute, or controversy, and coincided with and confirmed his sentiments of religion: he continued silently to search after truth, loving her for herself alone, and the thirst of the applause of the learned never once disturbed his tranquil existence. However, in the year 1776, his wife died; oppressed by grief for the loss of one whom he tenderly loved, and by the derangement of his domestic affairs, to which he had himself never attended, but for the consolation and assistance of his friends, his courage would have forsaken him, and he would for ever have abandoned his pursuits.

About eighteen months after the death of his first wife, perceiving that it was impossible at once to manage his domestic affairs, superintend the education of his six surviving children, and continue his pursuits as a physician and a naturalist, he yielded to the advice of his friends, and married Miss Sulzberger (of Leipsic), a lady estimable for her talents and virtues. She did not confine herself to ministering to the domestic comforts of her husband, but excited him to the acquirement of reputation for himself, and advantage to his family. Hedwig now resumed his labours with encreased ardour, and after having carefully revised his observations, and

repeated the experiments on which he founded his discovery, determined to publish a work in German, under the title of Observations on the true parts of Generation in Mosses, and on the multiplication of mosses by seed. This Work appeared in 1779.

Let us pause for a moment to observe with what caution and deference our author proceeded. He was then 49. He had for the last 20 years of his life been engaged in the study of cryptogamous plants, and it was five years since he had seen an anther of one of the mosses emit pollen, and with the exception of some months during which his labours were interrupted by grief, not a single day had passed without his examining some new species, and verifying his former observations. This was, indeed, very unlike many naturalists, who, on the first glance of any new fact, have hastened to advance some general positions which they conceive themselves afterwards bound to support. Hedwig had spent his life in collecting facts, and would not consent to publish that which he had not proved satisfactorily to himself by every means in his power; and never having pinned his reputation on any particular theory, he might, on any new discovery or on the occurence of any new reason, change his opinion without the interference of his feelings or his prejudices.

He sounded the opinions of his countrymen in a simple memoir written in his native language. At the age of fifty he appeared to have achieved little; but we shall soon perceive the advantages he had gained by having thus, during his long retreat, amassed such a store of materials.

Hedwig was too little known and too unconnected, for his work, written in German, at once to attract any great share of the public notice; his wife, finding that the practice of physic in so small a town as Chemnitz could not furnish her husband with means of educating his children, and that his talents would remain in obscurity, persuaded him to remove to *Leipsic*, where he established himself in the year 1781. In the year following he published his discovery in Latin under the title, *Fundamentum historiæ naturalis Muscorum frondosorum.*

This work, which was the result of twenty years study, con-

tained all that was requisite to be shown respecting the dissection of the mosses, their impregnation and propagation, and, finally, a new system for the arrangement of them in genera, according to the characters drawn from the form and situation of the parts of fructification.

The attention of botanists was attracted by the singularity of the facts stated in this work, and every one was eager to ascertain their truth by actual experiments; the study of cryptogamous plants came into vogue, and thenceforward nearly all the publications contained the mosses classed according to the new arrangement of Hedwig. Those who did not adopt his genera or his nomenclature availed themselves of his characters. His theory, notwithstanding, was impugned by several distinguished naturalists; and what theory was ever put forth that was not combated? But all discussions are useful, and objections to a theory, when answered, serve but the more firmly to establish its truth.

The academy of Petersburg having offered a prize for the determining the parts of fructification of the cryptogamous plants of Linnæus, Hedwig sent a very extensive treatise on the subject, and the prize was decreed to him by the academy, and his work was published in 1784. Soon after this he had to repel some fresh attacks which were ably combated.

His defence, as far as regards the mosses, appears to be unanswerable; but his doctrine relating to the ferns, though exceedingly ingenious, is not so completely proved; and the positions respecting the lichens and mushrooms are mere conjectures, unsupported by facts.

Up to this period Hedwig's life had been spent in poverty and obscurity, but his works having established his reputation in the scientific world, his talents were (though somewhat tardily) about to acquire their reward. In 1784 he was made inspector of the military hospital at Leipsic, and two years afterwards was nominated to the professorship extraordinary to the faculty of medicine. In 1789, the Elector of Saxony *(Frederick Augustus)* nominated him to the botanical professorship, and to the superintendance of the garden, and gave him apartments at the academy. Some difficulties arose on his

appointment: according to the established regulations he was ineligible, on account of his having been admitted Doctor without having first taken his degree of Master of Arts, and it was then too late to remedy this: but the Elector himself interfered and removed all obstacles, judging, that acknowledged merit, like Hedwig's, should not be subjected to rules framed merely to guard against the election of improper persons.

Thus an honourable exception from the rule was made in favour of one, who had in the outset of life been refused permission to practise as physician in his native town.

It might be supposed that the new employments of Hedwig, the celebrity he had acquired, his pupils, the discussions in which he was involved with his critics, and the distractions incident to so sudden an accession of honours and fortune, would have left him little leisure to write any new work; it was to be expected that he would have confined himself to his labour on the cryptogamic plants, but he had been incessantly studying nature for five and thirty years, and if he had postponed publishing the result of his observations, it was that they might be compared and contrasted together, and given to the world not as insulated facts, but as forming part of a general system of vegetable physiology. Different treatises, each of which appeared to have required long research, followed each other in rapid succession; but nothing more was required, than the time for writing them, because the materials had been long since arranged in his own mind, each, in fact, being nothing more than an extract from his vast store of knowledge acquired during his long studies and observations.

Hedwig, almost immediately after his History of the Mosses, published successively.

1. *A treatise on the origin of the parts of fructification,* in which he refutes an error of Linnæus, shewing that the stamens and pistils are produced by the same vessels as the other part of the plant, and not by the pith, as Linnæus had supposed.

2. A memoir on the cotyledons.

3. A dissertation on bulbiferous plants.

4. A memoir on the organs of transpiration in plants.

5. An examination of the distinctive characters of plants and animals.

6. An answer to certain questions proposed by Dr. Arthur Young on the irrigation of meadows with spring-water.

7. A dissertation on the origin of the vegetable fibre.

8 Observations on the use of the leaves in plants.

9. A memoir, in which, after having described the sexual organs of several *cucurbitacées* at the time of fecundation, he considers the manner in which the pollen impregnates the ovaries, and the changes which this phenomenon produces in plants.

10. Notes on the Aphorisms of Humboldt, in which he lays down several principles of vegetable physiology.

11. Lastly, considerations on the present and future state of the Science of Botany, and on the best means to be pursued in the study of it.

In the foregoing list only the principal works of Hedwig have been enumerated; there are a vast number of others written by him on agricultural subjects, and on the establishment of different genera. His last work was a new edition of his Theory of the Order Cryptogamia; in which he treats his subject at greater length, corrects the errors which had escaped him in the former edition, answers the objections which had been brought against his theory, and lays down some rules for making observations and for the use of the microscope, and for the means of obviating the illusions of that instrument. The perusal of this work removes all doubts which could arise respecting the truth of the facts observed by him, or the accuracy of the figures which accompany his descriptions.

These different treatises were published between the years 1779 and 1798: and besides the before-mentioned works, our author published in parts his *Stirpes Cryptogamicæ*, consisting of four volumes in folio, comprehending an analytical description of 148 species of mosses, and 50 other cryptogamous plants, all examined with the microscope, and figured with great elegance and truth: he also prepared a general history

of the mosses; in which he characterised all the known species, and gave drawings of all such as had not been figured before. This work, which he did not live to finish, was arranged and published from his manuscripts and drawings, by Frederick Scwægrichen; it contains notices of 360 species, of which 157 are figured.

Hedwig had six children by his second wife, five of whom died young; one of his daughters, whose education he had himself superintended, died at the age of sixteen years, of the small pox. This misfortune overpowered him; it was in vain that he attempted to conquer his grief by an unremitting attention to his pursuits; his strength was exhausted, and repose, which left his mind a prey to sorrow, was absolutely necessary to his bodily health. Having continued during the severe weather at the end of the year 1798 to visit his patients, without adopting proper care to defend himself from the cold, he was attacked by a catarrhal fever, from which he was scarcely recovered before he was carried off by a nervous fever, at the end of nine days, on the 7th of February, 1799, in the 69th year of his age: of 15 children four only survived him, two daughters and two sons, one of whom, M. Romain Adolphus Hedwig, Professor of Botany at Leipsic, published his father's work on Ferns, with figures by himself.*

Hedwig was endowed with a remarkable good sight, and a very neat and skilful hand, qualities which were of peculiar use to him in the pursuits in which he was all his life engaged. His memory was prodigious, and enabled him to compare his observations and experiments with every thing of the kind he had done from his earliest youth. He retained to the last the habit of making long botanical excursions; the young students who used to accompany him were astonished at his perseverance. These expeditions were considered by them as parties of pleasure. Hedwig used to explain with simplicity his principles, and his discoveries, and taught them to make correct observations: and when in a wood, seated in

* Mons. Deleuze observes, that he is indebted to Mons. R. A. Hedwig for his assistance in furnishing him with information respecting his father.

the shade, he found himself in the midst of those minute plants of whose principal organs he had been the discoverer, he felt inspired with all the vigour of his former youth.

His scholars respected him as their father, and treated him with that kind familiarity which arises from confidence, and a common love for the wonders of nature, a love with which he inspired all his pupils: " I have known many," adds M. Deleuze, " and they all spoke of their former master with affection."

He was revered by his family for domestic virtues. The celebrity he so suddenly acquired was no doubt flattering to him; he was sometimes disturbed by the illiberality of criticism: but neither the pleasures nor the pains arising from his literary fame, materially occupied his mind; his greatest pain and his greatest pleasure, alike sprang from the affections of his heart. In his last illness, being terrified by the appearance of phantoms, arising from nervous irritation, " Reach me your hands," said he, calling his wife and daughter, " whilst I feel you near me my terrors leave me."

From the foregoing account it appears, that by far the greater part of the life of Hedwig was employed in collecting facts, and making observations and comparisons; and not appearing in the career of science till at an advanced age, he astonished every one by the singularity and importance of his discoveries, by the multitude of proofs by which he supported them, and the number and the variety of his works.

Art. XV. *Proceedings of the Royal Society of London.*

After the Christmas vacation, the Society met on Thursday, the 11th of January, when a Paper communicated by Sir Humphry Davy, was read, giving a further account of the construction of safe lamps for coal pits, his earlier inquiries connected with this subject, having already been submitted to the Society at the Meetings of the 9th and 16th of November.

The present Paper relates chiefly to the singular effect produced by surrounding the flame of a lamp with wire gauze, which enables us to burn it without danger from explosion, in mixtures of fire-damp, which, on the contact of naked flame, would instantly detonate.

This Paper was followed up by a second on the same subject, read at the Meeting on the 25th of January. It is unnecessary to dwell upon the value of these communications, either on account of the new philosophical truths which they announce, or their much more important application to the practical purposes of the miner, the Council of the Royal Society, seeing the propriety of giving speedy circulation to such inquiries having liberally sanctioned their immediate publication. In the first Article of the present Number, some additional observations will be found relating to these lamps, and in Mr. Hodgson's letter, their secure practical application is amply demonstrated.

On the 25th of January, the reading of a paper by Dr. Wilson Philip of Worcester was commenced, which was continued on the 1st of February, and concluded on Thursday the 8th. It related principally to the influence of the Nerves upon Secretions, a subject which has long attracted the attention of physiologists, but upon which, from its extreme difficulty and intricacy, very little light has hitherto been thrown by experimental investigation.

It has been long known that when the nerves which supply the voluntary muscles are deranged or divided, the powers of the muscle are interfered with, and that any injury done to the nerves which supply the organs of secretion, interrupt, or modify the functions of the gland, and the composition of the secretion. A remarkable instance of this very often occurs where the action of the kidneys is interfered with by damage done to the spine, in which case the urine is secreted turbid and alkaline. The consideration of these, and many similar facts, have long led physiologists to regard the nerves as presiding over secretion in general; in 1806, such a doctrine was maintained by Berzelius in his work upon Animal Chemistry, and in the Phil. Trans. for 1809, and in the Philos. Journal

for the same year, Sir Everard Home and Dr. Wollaston have each adduced evidence in its favour. The latter experimentalists too have shewn, that it is more than possible that electricity may be concerned in the hidden agencies of the nerves. This notion is adopted and strenuously defended by the author of this Paper, a great part of which is taken up in the detail of harsh and unsatisfactory experiments upon living rabbits. That the function of digestion is connected with the operation of the eighth pair of nerves, Dr. Philip proves by feeding rabbits with parsley, and immediately after dividing those nerves in the neck. After some hours, the animal was killed, and the parsley found unchanged in the stomach. In another experiment the rabbit was fed, and the nerves divided as before—their extremities were covered with tin foil, and the hair opposite the stomach being removed, a shilling was laid upon that spot—the foil and the shilling were then connected with a battery of 47 four-inch plates, the action of which was continued by dilute muriatic acid for twenty-six hours, when the animal was killed, and the parsley was as perfectly digested, says Dr. Philip, as in the stomach of a healthy rabbit. Hence Dr. Wilson Philip concludes, *that nervous influence and galvanic influence are identical.*

These conclusions are by no means verified by the researches of other experimentalists, who, by similar means, have been led to very different results; nor does Dr. Wilson Philip seem to have made them with sufficient precision, to justify the inferences drawn from them.

The remainder of the Paper related principally to the generation of heat in animals, which Dr. Philip refers, with Mr. Brodie, to the influence of the nerves. He considers animal heat as a secretion.

On the 8th of February, a Letter to the President from Dr. Brewster was read, relating to some optical Properties of Fluor Spar and common Salt. (See Article XVI.)

Feb. 15. Two mathematical papers were communicated by the Rev. Dr. Robertson; the one shewing a Mode of calculating the excentric from the mean Anomaly of a Planet; the other containing a Demonstration of Dr. Maskelyne's Method

of finding the Longitude and Latitude of a celestial Obje c from its right Ascension, and *vice versâ;* and shewing some Errors to which this Method is liable. These Papers did not admit of being read at length.

On the same evening was read a Paper by Mr. Todd, containing some curious observations on the Torpedo, the structure of whose electric organs has been long ago described by Mr. Hunter. He pointed out the immense relative bulk of the nerves which run to that organ. Mr. Todd shows by several satisfactory experiments, that the animals are much debilitated by the use of the electric apparatus in giving shocks: that they live longer and are more vivacious when it is little employed, or when their power over it is cut off by the division of its nerves. No new light is thrown upon the *modus operandi* of this electrical apparatus.

Thursday, Feb. 22. Sir Everard Home presented an account of the Feet of those Animals, whose progressive motion can be carried on in opposition to gravity.

It is well known, that the house-fly is capable of walking upon the ceiling of rooms, in which situation its body is not supported on the legs; but the principle upon which it does so has not been explained, because the animal is too small for the feet to be anatomically investigated.

Sir Everard was not aware that any animal of a much larger size was endowed with the same power, till Sir Joseph Banks told him that the *Lacerta Gecko,* a native of the island of Java, was in the habit of coming out of an evening from the roofs of the houses, and walking down the smooth hard polished chunam walls in search of flies that settle upon them, and then running up again. Sir Joseph, while at Batavia, was in the habit of catching this animal by standing close to the wall with a long flattened pole, which being made suddenly to scrape its surface, knocked it down. He procured Sir Everard a specimen of a very large size, weighing five ounces three quarters avoirdupoise weight, which enabled him to ascertain the peculiar mechanism by which the feet of this animal can keep their hold of a smooth hard perpendicular wall, and carry up so large a weight as that of its own body.

Sir Everard particularly described the anatomy of the foot of this lizard, which is so constructed as to enable it to produce a number of small concavities which act like so many cupping glasses, and atmospheric pressure retains him in his position. The author, having ascertained the principle on which an animal of so large a size as this is enabled to support itself in progressive motion against gravity, felt himself more competent to examine into the mechanism by which the common fly supports itself with so much facility in still more disadvantageous situations. An account was then given of the structure of the fly's foot, which shewed that it possessed concave surfaces capable of acting in the same manner as those of the Lacerta Gecko: and that therefore its progressive motion against gravity was effected by the same means.

ART. XVI. *Proceedings of the Royal Society of Edinburgh.*

Nov. 6. THE Society met for the first time this season, Sir James Hall in the Chair. An account of a meteoric Stone which fell near Bombay, communicated by Capt. Hall, F. R. S. E. was read. This account had been translated from the Persian of SYED ABDULLA; the circumstance took place on the 5 Nov. 1814, and differs in no respect, from the other well authenticated accounts of the same kind, and is chiefly interesting from the mode in which this Eastern philosopher accounts for the phenomenon. After enumerating the number of stones found, he observes, " the causes of this may be, that " in the course of working (or of changes on) the ground, air " being extricated, may have entered into combination, and " come near elemental fire, and from this fire have received a " portion of heat; that then it may have united with brimstone " and terrene salt, as for instance, saltpetre; when the mixture, " from some cause, being ignited, the fire bestows its own

" property on the mass, and the stones which may have been " above it are blown into the air.—God knows the truth."

Some observations by Capt. Hall, on some remarkable water spouts, were likewise communicated.

Nov. 20. Dr. Brewster read a Paper on the optical properties of Fluate of Lime and of Muriate of Soda.* Also a Paper by Dr. Murray was likewise read, entitled Observations on the Fire Damp of Coal Mines, with a plan for lighting them so as to guard against Explosion. The plan by Dr. Murray being already before the public, we think it unnecessary to detail his ingenious paper.

Dec. 4. Mr. Playfair communicated an account of some experiments, in which he had assisted, made at Woburn Abbey, in August last, for determining the proportion between the load and draught of horses in waggons. The instrument used in these experiments for measuring the quantity of the draught, was a Dynamometer, or, as it were perhaps better to call it, a *Sthenometer*, of a different construction from that of General Regnier, and the contrivance of Mr. Salmon, at Woburn, already known in the mechanical world for many ingenious inventions, One general result from the experiments was, that in a four-wheeled waggon of the ordinary construction, on a good road and on a horizontal plane, the draught is between a 25th and a 30th of the load. If the load, for example,

* Malus and other philosophers who had examined this class of crystals, announced that they did not possess the property of double refraction. In using large masses, however, of considerable thickness, Dr. B. found that muriate of soda, fluate of lime, alum, and the diamond, not only possessed this property, but possessed it in a manner different from all the other crystals of the mineral kingdom. These crystals combine in the same specimen the structure of both the classes of doubly refracting crystals. In one part of their mass, they have the same structure as calcareous spar and the other minerals of the same class; while in another part of their mass, they have the same structure as sulphate of lime and the other crystals of that class. In some parts of these minerals, the property of double refraction is not at all exhibited,

be one ton, or 2240 lib. the draught is between 75 and 89 lib. Several other general results were deduced.

A Paper by Dr. Dewar, on the Education of Mitchell, the blind and deaf Lad, was next read.

The melancholy situation of this unfortunate young man, has long been a subject of much solicitude among the Members of the Royal Society of Edinburgh; of the circumstances of his unfortunate case the public have already been put in possession, by the interesting Memoir by Prof. Dugald Stewart, which appeared in the last volume of their Transactions. An attempt has subsequently been made, to obtain some small annuity from government, to be settled upon him and his sister, with the view of enabling them to remove from a remote quarter of Scotland, to the neighbourhood of the capital, in order that he might not only be provided with the best medical assistance that could be procured, but also that so singular a case might be placed under the inspection of men of science. It is to be regretted their benevolent intentions were not attended with success.

Dec. 18. Dr. Brewster read an account of a chromatic Thermometer.

This instrument is founded upon a new property of heat, in consequence of which a plate of glass is thrown into a *transient* state of crystallization, during the propagation of heat through its mass. When the glass is in this state, it acts upon polarised light like regularly crystallized bodies; it produces various orders of colours in different parts of the glass plate. The number of fringes increases, or the tints rise in Newton's scale, as the temperature of the source of heat is increased; so that the difference between the temperature of the glass and that of the source of heat, is measured by the number of the fringes, or the nature of the tints which are developed. As every tint in the scale of colours has an accurate numerical value, differences of temperature may be measured with the utmost correctness, from the lowest temperature up to those at which glass begins to lose its solidity.

The heat of the hand applied to a single plate of glass *three-tenths* of an inch thick, produces a perceptible effect in

crystallizing the plate; so that, if *ten* plates were employed, a difference of temperature, equal to one-tenth of that which was applied to the single plate, will be distinctly appreciable.

Dr. Hope communicated a Plan for lighting Mines so as to avert Danger from Fire Damp.

Jan. 8. An Analysis of Sea Water, was read by Dr. Murray. An account of some Experiments on Light, by Dr. Brewster; and an account of some Veins of Greenstone which traverse the Granite of Sable Mountain, communicated in a letter from Mr. Jukes.

Feb. 5. At this meeting, Mr. Playfair read some extracts from a memoir of the Comte La Place, not yet published, on the application of the calculation of probabilities to natural philosophy. The general object of that application is, to determine the degree of probability, that the error of a result, obtained from the comparison of certain experiments, is contained within given limits. The extracts referred particularly to the determination of the figure of the earth, from the experiments made on the vibration of pendulums. From a selection of 37 of the best of the experiments made on the length of the second's pendulum in different latitudes, La Place finds that the increase of gravity, from the equator to the poles, follows the law which theory points out as the most simple; and hence he conceives, that the density of the layers, of which the mass of the earth consists, must augment regularly from the surface to the centre; a condition from which he thinks it reasonable to infer the original fluidity of the whole mass of our planet; a state, he adds, which nothing but the action of excessive heat could produce in the whole mass of the earth.

From the formula for the length of the second's pendulum, deduced from the 37 experiments just mentioned, Mr. Playfair finds the length of the second's pendulum for London, in English inches 39.13009. This agrees in the first three decimal places with the number 39.13047 put down in the bill for the equalization of weights and measures. It is probable, therefore, that those three decimals are correct, but that the other two are not to be relied on. A series of experiments

on the length of the pendulums, made with more accurate instruments than we have yet employed for that purpose, is greatly to be desired.

Mr. Russel read an account of an Animal found in Horses Eyes in India.

Feb. 19. Dr. Brewster communicated an account of the sleeping Woman of Dunninald near Montrose, drawn up by the Rev. James Brewster, Minister of Craig. Margaret Lyall, aged 21, daughter of John Lyall, labourer at Dunninald, was first seized with a sleeping fit on the 27th of June, 1815, which continued to the 30th of June; next morning she was again found in a deep sleep—in this state she remained for seven days, without motion, food, or evacuation—but at the end of this time, by the moving of her left hand and by plucking at the coverlet of the bed and pointing to her mouth, a wish for food being understood, it was given her—this she took, but still remained in her lethargic state till Tuesday the 8th of August, being six weeks from the time she was seized with the lethargy, without appearing to be awake, except on the afternoon of Friday the 30th of June—for the first two weeks, her pulse was generally about 50, the third week about 60, and previous to her recovery, at 70 to 72. Though extremely feeble for some days after her recovery, she gained strength so rapidly, that before the end of August, she began to work at the harvest on the lands of Mr. Arkley, and continued without inconvenience to perform her labour.

The account is drawn up by the Clergyman of the parish, and is accompanied with the medical report of the surgeons who attended; to whose attestations are added those of Mr. Arkley, the proprietor of Dunninald, and Lyall, the father, and is in every respect entitled to the fullest credit.

Mr. Playfair read a paper on Barometer Tubes. Mr. Playfair observed, that the difficulty which had been hitherto most severely felt, in making barometrical observations in mountainous or remote countries, proceeded from the fragility of the instruments, which being necessarily made of slender and very brittle materials, were frequently broken, and the opportunity of making observations disappointed, after much

labour had been bestowed on the attempt. Metal, from its want of transparency, could not be used in the common manner, still however, it might be so applied as to become available with so considerable a degree of accuracy, as to render the instrument of the greatest utility—the plan proposed by the Professor, was to adopt iron tubes, of one quarter of an inch calibre, and of the usual length of the barometer tube; that these should be accurately bored, and closed at one end; mercury, if carefully poured into them, would be tolerably free from air, but if necessary, any air that might be carried down with the mercury, could be expelled entirely by means of an iron wire, which was often used even with glass tubes, or by means of heat; the tube thus prepared, could be carried with perfect safety any where. To use it, it was only necessary to place the finger on the open end, and to invert it in a cup of mercury, when the tube being suspended and allowed to remain until the oscillation subsided—the finger might again be gently replaced on the open end, and the tube re-inverted, when the quantity of mercury deficient would afford the data of calculation—this quantity might be measured with accuracy by means of a float, having a graduated stem, and lead to an approximation sufficiently near the truth for all useful purposes.

Instruments are now in the hands of workmen, with the view of putting this invention to the test.

On Monday the 4th of March, a Paper by Dr. Brewster was read, on the probable Existence of a new Species of Rays in the solar Spectrum, apparently produced by the collision of the particles of light when emitted from the sun's surface.

Art. XVII. *A Report on a Memoir of Mons.* Methuon, *entitled, " Découverte de la Manière dont se forment les Cristaux terreux et metalliques non salins, &c."* *By* A. B. Granville, *M. D. M. R. C. S. &c. For. Sec. G. S.—Read before the Geological Society, the 16th of February,* 1816.

The Society having expressed a wish to know the substance of a memoir on a curious subject connected with the crystalline modifications of minerals, written by Mons. Methuon, one of the chief engineers of the mines in France; I have lost no time in drawing up, for their information, the following short analytical account of its contents.

The Paper in question is known to but a limited number of scientific persons in France; and to two or three individuals only in this country. It was forwarded to me from Mons. *Gillet de Laumont* by the Count *de Bournon;* and the circumstance of my having been desired to return it immediately after its perusal, induces me to believe that but few copies of it are in circulation; which is highly probable, when it is considered that the author, from his residence in the country, and from some other circumstances detailed in his Memoir, has hitherto been precluded from every opportunity of fairly bringing his object before that great circle of scientific men, who in France, more than in any other country, seem confined to the capitals, from whence they appear exclusively to command the credit and the admiration of that empire.

Mons. Gillet de Laumont accompanies the Memoir with the following expression in his letter to me; " l'auteur du Mémoire sur les cristaux factices est un homme non capable d'en imposer; mais qui n'a peut-être pas toutes les connaissances chimiques nécessaires pour bien exposer ce qu'il a fait, et la théorie qu'il en deduit." This elucidation was by no means unnecessary, both on account of the ill digested diction in which the communication is made to the public, and from the writer of it announcing, in the most positive manner, a discovery of a most novel and highly important nature. This consists

in nothing less than "in having *ascertained* the mode in which *earthy* and *metallic* crystals, not of a saline nature, are formed: and in having devised an apparatus by which such crystals may be *artificially* obtained in very abundant crops."

An historical relation of those facts by which the author was led to the adoption of his present views on the subject, precedes the account of the discovery and of the opinion he entertains of it. These are followed by a number of aphorisms, and theorems derived from actual observations; and the Paper concludes with a description of the above-mentioned apparatus.

Amidst the obscurity of the language, it is not difficult to discern an evident aim at overthrowing the celebrated system of Haüy; but such an hazardous attempt of the author ought not to prepossess us, too hastily, against him.

Crystals, according to Mons. Methuon, are not the immediate consequence of undisturbed solution or fusion; but the produce of a peculiar decomposition of amorphous crystallizable masses, the particles of which arrange themselves, during decomposition, according to certain laws of attraction; the process being carried on in the dry way, and in the air. This is Mons. Methon's theory. His facts are by far more interesting, and, if genuine, really astonishing.

About twelve years ago M. M. had occasion to visit the western coast of the island of Elba. While there engaged in some mineralogical pursuits on one of the mountains, his attention was directed to a block of *argillaceous schistus with pyrites*, which appeared to have been recently detached from a stratum of that substance, forming the basis of a large mass of *sandstone* projecting from one of the sides of the mountain. On examining it he found that several capillary crystals of alum from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in length covered its superior surface. This, as well as the lateral sides of the stone, were in an evident state of decomposition more or less advanced, to the depth of $1\frac{1}{2}$ inch. There was some dust lying in the intervals between the crystals, which he blew off; and he observed, that the wind had previously scattered some of it around the stone as it lay on the earth. Struck

with this singular appearance, and almost instantaneously seizing the hint from nature, Mons. Methuon raised with sticks an appropriate shelter, under which he placed the mineral, and frequently paid a visit to the apparatus. The elongation of the crystals and the accompanying decomposition of the stone, became every day more visible, until, at the end of two months, the *former* were nearly double in size, and the *latter* had increased in proportion.

"This discovery of the alum," exclaims M. Methuon, "being formed in the air, and not in water, made a strong impression upon me, and I confess I could not forbear thinking there existed some analogy between this formation, and that of the *earthy* and *metallic* crystals not of a saline nature. It was evident, indeed, that the alum, in this case, did not exist in the rock, but was the immediate effect of its decomposition; that a portion of the sulphur from the *pyrites* passed into the acid state by means of its contact with the atmospheric air; and that this acid, combining with the argil, formed the crystals of alum."

Mons. Methuon lost no opportunity of verifying his conjectures respecting this phenomenon; he repeated his observations, multiplied his experiments, and finally succeeded in obtaining both *earthy* and *metallic* crystals in the manner he afterwards describes.

Encouraged by so flattering a prospect, the author immediately instituted more particular enquiries, and searched every recondite place in the island, in many of which, he asserts that he found recent crystals formed from a decomposition of the amorphous masses in which they were implanted. Nay, at one time, he seems to have caught nature in the very act of forming crystals of quartz on a mass of *silico-calcareous* earth, from the surface of which M. Methuon had carefully removed all signs of pre-existing crystallization. The author marked the spot well, and left it. After a few weeks, some small points of rock-crystal made their appearance; by degrees the pyramidal summits were formed; and these were gradually followed by the prism; its mass diminishing in size, as the crystal became more and more diaphanous.

At the end of three and twenty months, the period at which M. Methuon quitted the island, there were *six beautiful crystals of quartz*, from $\frac{2}{3}$ to $\frac{3}{4}$ of an inch in length, and $\frac{1}{3}$ of an inch in diameter; the silico-calcareous stone around them being excavated in the same proportion. But a fluid seemed, in this instance, to have had a part in the formation of these crystals; for, although the locality of the fossil producing them is described to have been beyond the reach of the waves, yet it is admitted, that their spray, particularly in tempestuous weather, often bedewed its exposed surface.

In a similar manner did M. M. obtain crystals of *yenite*, some specimens of which he has preserved to this moment.

A public mission into Piedmont furnished the next occupation of the author, and fresh opportunities for prosecuting his very curious enquiries. The same success attended him in this favourite country of mineralogists; for on removing some indistinct crystals of *alalite* and *garnet*, which he had discovered on breaking an amorphous mass of those substances, and on taking the proper precautions, consisting in throwing some loose earth and stones against the surface from which the crystals had been removed; after the lapse of six years, M. M. had the satisfaction of gathering a *second* and a *third* crop of new and beautiful crystals, formed during that period, some of which were sent to the public institutions at Paris.

But the author was destined to experience a still greater satisfaction, for having transported some of the crystallizable and shapeless mass of *alalite*, *garnet*, *green idocrase*, *pyroxene*, and amorphous *pyrites*; and formed with them an artificial mountain, which was placed on the chimney-piece in his room; after many days and weeks of anxiety, he had at last the pleasure of *seeing crystals of all these substances emerge from this heterogeneous mixture*." "The first," says the author, "which I had the satisfaction of seeing on my artificial mountain, were small prisms of *pyroxene*; next came the summits of crystals of *alalite*, then planes of *garnet*, after which those of *idocrase* and *peridot* followed in succession."

Such now became the author's conviction that he had, at

last, unravelled the hitherto unexplained secret of crystallization, that he felt he could supply, at pleasure, the cabinets of scientific men, with *new crops* of crystals from their own specimens. To this effect he ventured to demand of the Abbe Tonnelier, principal director of *l'Ecole des Mines,* in July, 1814, three specimens of *idocrase,* which were delivered to him after a most exact description had been made of them by Mons. Tonnelier himself, and acceded to, and signed by the author. These specimens were submitted to the *crystallizing process,* in November, 1814, and it is here asserted, that in April, 1815, the first specimen (which, from the description, appeared to have had only some crystals occupying little more than one-third of one of its surfaces) presented a zone of fine crystals crossing that surface in an oblique direction, and that two-thirds of another of its surfaces (on which no signs of crystallization existed before) were covered with a great number of very beautiful and distinct crystals. The second specimen had no crystal whatever, when delivered to M. Methuon, but by the following April, there were upon it, and in three distinct places, crystals of *idocrase* and *foliated talc*—while the third specimen, which offered only a small number of crystals on one of its angles, presented at that same period of time, several of them in three distinct places, one of the faces of the specimen itself having become striated, and perfectly crystalline.

These three specimens, thus enriched by newly formed crystals, after M. Methuon's method, have not yet been returned to the Cabinet des Mines. The author being obliged, from public duties, to reside at Lyons, has not yet had an opportunity to repair to Paris ; a journey, however, which he is in hopes of soon performing, when he will have the satisfaction of laying before the Abbé Tonnelier the singular and really astonishing result of his discovery. The author does not much lament this delay ; for he doubts not, but that in three or four months more, the specimens will have greatly gained, both in the size and beauty of their crystals.

And here I may be permitted to quote another letter I have received from Gillet Laumont, while occupied in drawing up

this report, in which the following information relative to this part of the subject is conveyed to me:

"J'attends l'auteur de la brochure, dont vous me parlez, sous peu à Paris. Il doit apporter les échantillons, sur lesquels on a dressé un procès verbal, et qui doivent contenir des cristaux nouveaux. Je n'ai pas osé publier son Mémoire avant, quoique j'aie *une grande confiance dans la véracité de l'auteur.* Je vous instruirai du résultat de l'examen, qui sera fait au conseil général des mines."

From a number of similar facts and observations, M. M. thinks it easy to conceive, that the natural process of crystallization originally begins in a partial decomposition of the surface of a *crystallizable* fossile; that from certain spots of this surface, where it has first begun, the decomposition proceeds in straight and narrow lines to other similar spots, which, in their turn, send forth similar lines, sometimes parallel to the former, at other times crossing each other at right, acute, or obtuse angles; thus dividing, or, more commonly speaking, carving, or engraving, the surface of the fossile into several compartments, which become, by a continuance of the process of decomposition, as many distinct pieces, constituting the body of the crystal in its rough state; and lastly, that during this process, the substances of a different nature, contained in the mineral, separate, and arrange themselves, in one or more parts of the same compartment, the fossile mass continuing to be solid and hard, but fragile and easy to be broken; the author having often broken, between his fingers, some, which had before withstood the strongest percussions.

The *corollaries* to these general assertions, laid down by Mons. Methuon, are many and distinct. But to understand the particular nature of his conclusions, a few of them will suffice. Mr. Methuon insists upon it being proved:

1st, That crystals begin to form at their summit, edges, and solid angles.

2dly. That nature produces, by a direct process, all simple and compound crystals, without first *forming* a *nucleus* in the latter.

3dly. That the *matter*, serving to form the crystals, is in the

state of a solid mass before, and continues in that same state during the whole process of crystallization. It may be called *crystallizable* matter.

4thly. That *crystallizable* matter is that which has filled, by infiltration, the chasms and clefts of mountains, and the cavities of rocks; which composes the veins, the stalactites, and the stalagmites; and, in general, all that which constitutes accidental formations found in *blocks, nodules*, &c. within large masses.

Founded upon these facts and conjectures, M. Methuon suggests the most proper apparatus for his *crystallogenous* process. This consists in forming a bed, one inch thick of loose earth, obtained from the decomposition of the stone in which the crystallizable matter is found, having an elevated *brim* of the same material round it, one-third of an inch in heigth. Some balls made of the same earth are disposed here and there on this bed, on which are placed various pieces of solid *crystallizable* matter, formerly known under the name of *crystalline matrix*. On these pieces other balls are properly disposed, serving to support some more specimens of crystallizable matter, so arranged as not to touch each other. The whole of it is then made as solid as possible, by the addition of other large and small balls, introduced wherever any space exists; and lastly, the apparatus is surrounded by a wall of bricks laid singly on each other, without any mortar, and in a way to admit a free circulation of air.

Every two or three days the whole apparatus is watered, so as to keep it in a state of constant humidity, and no more. A degree of temperature is maintained equal to the internal temperature of the earth; and the apparatus is examined every fortnight or three weeks, when, if necessary, the pieces may be carefully washed and replaced, taking care to arrange them so, that the balls which before were under, may now be placed above. After a certain lapse of time, the crystallizable matter is found to present distinct and beautiful crystal of the substances employed.

Such is the outline of the Memoir; the subject of which I have endeavoured to explain to the Society. I am aware that it is not of a description to find many who will readily believe

the assertions therein stated: but when a respectable man, devoted to science, and supported by the favourable testimony of persons detesting all shew of empiricism, comes frankly forward, and declares to have obtained the most extraordinary results in the course of his enquires, (publishing at the same time his principles and mode of practice, by following which we are promised the same success,) we certainly should not hesitate a moment in acknowledging, that no judgment ought to be formed of him, but such as springs from the most serious, impartial, and effective examination of his asserted claims to an important discovery.

Annotation.

The above report having excited the curiosity and the attention of several persons distinguished for their zealous application to the study of mineralogy and the doctrine of crystallization, an opportunity has been offered to me of witnessing the effects of dry decomposition producing regularly formed crystals in a specimen of feldspar, from America, now in the possession of Mr. Brooks, M. G. S., an account of which I have been favoured with by Mr. Webster, a medical gentleman from Boston. It is as follows:

"Three miles from Boston, and at some distance from the sea, is an extensive mass of sienite, one of the extremities of which is concealed from view by a superincumbent stratum of feldspar, in a state of disintegration at its surface, which is reduced to powder, and generally moist. Upon removing this powder from the surface, laminæ, composed chiefly of feldspar, are found more or less decomposed, and evidently assuming the incipient appearance of four and six-sided prisms, none exceeding three-fourths of an inch in length."

"The harder and more compact laminæ contain cavities from one-fourth of an inch to an inch in depth, in which crystals of feldspar are seen much harder, and of a superior lustre, and exhibiting the appearance of recent formation."

"The cavities and the crystals are constantly covered with

decomposed feldspar, in a moist state, which it is necessary to remove by washing, before the form of the crystal can be fully brought into view. These crystals have always been considered by the mineralogists of that country of more recent formation than the general mass, of which they constitute a part." 3d March.

Art. XVIII. *Miscellaneous.*

1. Letter from the Rev. J. Hodgson to Sir Humphry Davy, respecting the Use of the Safety-Lamp.

Dear Sir,

On the ninth of January, the day after the arrival of your lamps, with wire-gauze cylinders, I descended one of the shafts of Hebburn Colliery, for the purpose of making experiments with them in fire damp. Mr. Dunn, the resident viewer, Mr. Seymour, the under viewer, and some of the workmen attended me. Our first trials were made at the mouth of an iron pipe, which discharges fire-damp, conveyed from the same blower that Mr. Dunn procured the gas from, which I sent to you in the beginning of October last. It is occasionally lighted to serve instead of a lamp or candle in the horse-way; and we found it performing that office. The flame of the light was eight inches long, and of a corresponding breadth.

After blowing this gas light out, the lamp was held against the roof of the mine on the leeward side of the discharging pipe; and gradually advanced at that height till the fire-damp began to enlarge the flame of the lamp: as it was brought nearer, flashes, at intervals of a few seconds, played in the inside of the cylinder. These succeeded each other more quickly and vividly, as the lamp was lowered to a level with the mouth of the pipe, where the gas burned steadily in the inside of the wire tube, without communicating flame to that which surrounded it. Much heat and smoke were evolved

during this part of the trial; and the combustion, when the lamp approached near to the pipe, was carried on in the upper part of the cylinder; and the flame of the wick was extinguished in a luminous appearance. As the lamp was drawn back again, the same appearances were exhibited in inverse succession; and the flame always settled upon the wick, as soon as the lamp was taken into a due proportion of cooling atmospherical air. Our experiments here were varied in every possible way, and uniformly attended with the most convincing proofs of the safety of the lamp: but as often as a candle was tried to perform the office of the lamp, the gas fired at it with a sudden and bright flash, and continued to burn at the mouth of the iron pipe.

With these assurances of perfect security from danger, we entered the part of the mine where the fire-damp was discharging out of the fissures in the floor. In many places it could be observed forcing up the black, heavy salt water with a bubbling noise. The place, where the main feeders issued, was covered with a long air-tight trough, inverted in the water; and out of which the inflammable air was conveyed, through a wooden-pipe, to the place in the horse-way, where our first experiments were made. A current of fresh air, sufficient to render the fire-damp, which was not collected into this pipe, quite harmless, was constantly passing through this board or gallery into the adjoining horse-way.

We removed the end of the pipe inserted into the trough, and immediately applied a candle to the roof, bringing it in the windward direction towards the opening in the trough. In a moment the train of fire-damp lighted with a flash, not unlike that of ardent spirits thrown upon a fire; it was transient, but ignited the gas at the opening of the trough, where it continued to burn with a broad lambent flame, and much smoke, and disagreeable smell. Soon after it was extinguished, the same experiment was tried with the lamp, and with the same satisfactory appearances, as we had observed at the pipe in the horse-way: but far more perfectly and clearly exemplified here, on account of the greater discharge of gas:

for the conducting pipe was not perfectly air-tight from end to end.

We next placed a barrel with both ends out, over the opening in the trough; and after preventing the atmospherical air from ascending up it, by luting it round the bottom with clay, brought the lamp from the roof gently downwards into it: the fire-damp, like an unarmed and imprisoned enemy, struggled in the inside of the cylinder, to which its fury was invariably confined.

We found that if the lamp was gradually introduced into explosive mixtures of gas, it continued to burn as long as the atmosphere around it contained oxygen; but if it was suddenly plunged into highly explosive mixtures of fire-damp and common air, the flame was soon extinguished.

After varying the experiments here in every way we could think of, and always with the same uniform success, I ascended the shaft with the lamp still lighted; and walked with it to Mr. Dunn's house, about the distance of 300 yards, with a considerable breeze attended with sleet, blowing in my face, and the light continued to burn without any attention on my part to preserve it

On Monday, the 17th of January, I went down the same pit with Mr. Buddle and Mr. Dunn, when our former experiments were repeated, but in explosive atmospheres of greater extent; for we not only lessened the current of fresh air passing through the board, where the blowers of fire-damp issue, but suffered that damp to collect around us for a longer time than we had done on the preceding Tuesday.

After the place where we stood had partly stagnated for about half a minute, a candle was raised gently to the roof of the mine, and cautiously advanced to windward from the leeward side of the opening in the trough. The inflammable train soon reached the light, and exploded along the roof, attended with a very sensible shock. It flew from us against the current of fresh air, and kindled the gas issuing from the rents in the floor and sides of the board, which continued to burn till they were dashed out. But when the lamp was put to similar tests, it went through air in every degree of

explosive state, from the slightest to fire-damp in the greatest purity that the mines produce it; and retrograded through the same deleterious atmosphere, without either communicating flame to the outside of the cylinder, or being extinguished.

These trials were sufficient to remove the most distant idea of doubt, respecting the safety afforded by the lamp. But that it might be used in some practical sort of way, we took it into a board where a man, by the light of a steel-mill, was hewing the pillars of coal which had been left when the mine was first wrought over, and which, by the pressure of the superincumbent strata, had sunk into the schistose stratum which composes the floor.

All the parts of the mine here were so crushed and shattered, that a grinding noise of the dislocated strata could be distinctly heard over our heads: though the roof was supported by props and crown-trees (lintels) of wood placed nearly side by side. In places of this kind, the sides of the boards in which the men are working, are often so rent, that the fresh air cannot, without the greatest difficulty, be conveyed along them to dilute the great discharge of fire-damp. It filters off through the new pillars of broken schist, and thus unavoidably renders the mine exceedingly close and warm.

In the place we had now entered, it was considered quite unsafe for the men to work with a candle; though at the moment of time we were there, the air perhaps would not have exploded at a naked flame. The lamp, indeed, burned with a very slight increase of brilliance: and near the roof the flame of its wick spired slightly into length, and the copper plate and the ring at its top very sensibly increased in warmth for the space of half a minute, during which time, I suppose, all the fire-damp within its influence was consumed.

The experiments I have been witness to under ground, ended here. But Mr. Buddle, Mr. Dunn, and other practical gentlemen, who have seen the lamps used in places that have not been ventilated for several years, will be able to give you still more satisfactory accounts of their great utility, and the security they afford the miner from danger by explosions.

The simplicity of the lamp, in my mind, is not more remarkable than its security. If the men be only careful to trim it with clean cotton about once every third time it is used, to keep up a constant supply of clean oil, and never to raise the wick so high as to cause it to smoke, it will give as good a light as a candle and be less troublesome: but if they suffer a smoke to fly off the top of the flame, it will fill the apertures of the cylinder with soot. When first lighted, the wick ought to be cut straight with a pair of sharp scissors, and not suffered, while it is burning, to get encrusted with coaly specks, or get jagged, in which states it is sure to smoke and burn dimly.

Another excellence of the lamp is, that in case of a stone falling upon it from the roof, the light can scarcely be exposed to the open air; for such an occurrence would either instantly extinguish the light, or merely bruise the cylinder; for the flexible nature of the wire and other materials of the lamp, render it almost impossible to break any part of it by a stone or weight falling upon it.

I also feel persuaded, that the wire-gauze cylinder will give a steady and abundant light in mixtures which would explode with great fury at a candle; and that it will continue to be highly useful, when sparks from a steel-mill are too dull and feeble to afford the miner any assistance. In short, that the miner may continue to work with them, as long as the air around him can be safely respired.

I am, dear Sir Humphry,

Your's very respectfully,

JOHN HODGSON.

2. A few months ago, Messrs. Graham and Railton discovered, upon their premises in Mansion-house-street, an old well which was full of burned wood; upon removing this, and a quantity of black mud beneath it, they found several bottles of a globular shape, with short necks, the exteriors of which were considerably decomposed from the loss of alkali, and the silicious earth peeled off in films. One of these contained

some excellent wine, having the flavour and appearance of Malaga—the others were full of a liquor which appeared to have been Port-wine, but the spirit was almost entirely converted into vinegar, and the vegetable matter was in a state of putrefaction. The colour was that of tawney port. The white wine contained 18 per cent. of alcohol, while the red afforded only three per cent. It is curious, that in regard to the former, the wine and cork were more sound than the bottle. From the antiquity of the premises, the quantity of burned wood in the cellar, the ancient form of the bottles, the perishing state of the glass, and other circumstances, it is plausibly conjectured that the wine was of anterior date to the great fire of London, which occurred in 1666. When the bottles were opened and their contents examined, there were present Sir Robert Graham, Mr. Joseph Railton, Dr. Cooke, and myself.

A large quantity of Greek wine under the name of Lissa, or Dalmatian wine, has lately been imported into this country: the quantity of alcohol which it contains is in some samples as high as 26 per cent., in others it amounts to 24. It contains a remarkably large proportion of malic acid.

I have lately examined two samples of genuine Marsala from Sicily; the one contained 25.5, the other 26.3 per cent. of alcohol: this therefore, and the Lissa, stand higher as to alcohol than any of the wines set down in my Table of the strength of wines, published in the Phil. Trans. for 1811. In regard to this Table, it may be worth remarking, that in Sir Humphry Davy's Lectures on Agricultural Chemistry, *octavo edition*, and in Dr. Henry's Elements of Experimental Chemistry, (*7th edit. Vol. II. p.* 259,) the largest quantity of alcohol in Port-wine is misquoted from the above Table—it is stated as=35,83 per cent., whereas it should be=25,83 per cent.

W. T. BRANDE.

United States of America.

The Literary and Philosophical Society of New York, established and incorporated in the year 1814, have lately offered to the Public the first volume of their Transactions in large 4to. This volume, besides the elaborate and valuable Discourse of the President, contains a large body of interesting and novel information, relative to the literature and science of the American States.

The American Ornithology is at length completed by the appearance of the 9th volume. Mr. Wilson, in this celebrated Work, has figured and described 278 species of the feathered tribe of the United States, 56 of which are asserted to have not been known before.

Drs. Hosack and Francis, of New York, have recently completed the publication of the fourth volume of the American Medical and Philosophical Register, a Periodical Journal devoted to medicine, surgery, and the collateral branches of knowledge.

Professor Cooper, of the University of Carlise in Pensylvania, has just published a volume on calico dyeing, for the benefit of American manufacturers.

Dr. Hosack is about to lay before the Literary and Philosophical Society of New York, the results of his experiments and observations on the mode of communication existing between the mother and fœtus. It is familiary known, that physiologists are much divided in opinion on this interesting subject; and Dr. H. we are informed, is disposed wholly to reject the present received doctrines concerning it. He denies to the placenta the office of lungs, and maintains that the blood, already oxygenated, passes by direct communication from the mother to the fœtus in utero. He has long inclined to this belief, and in 1807, promulgated these opinions as teacher of Midwifery in the University of New York.

The Next number of this Journal will contain an account of the Lectures delivered in the Royal Institution, during the present season.

A Descriptive Catalogue of the British Specimens deposited in the Geological collection of the Royal Institution is just published.

These specimens were principally collected with a view of exhibiting the most remarkable phenomena of stratification, of elucidating the leading controversies of theorists, of showing the products peculiar to particular districts, and of giving a general outline of the Geology of Great Britain. The Catalogue comprises a sketch of all the most notable associations of the strata, their peculiar localities, the order of their succession, and their relation to the different superficial soils, and connects in one view the hitherto widely-scattered observations upon the mineral features of our country.

To render the collection complete, however, much yet remains to be effected; some extensive chasms, and several smaller breaks in the series, must be filled up by the insertion of illustrative specimens; and some errors corrected by more accurate and extended observation; but it is hoped, that when these defects are discovered, they will be remedied; and that those who have so liberally forwarded other objects of the Institution will not withhold assistance on the present occasion.

Art. XIX. Meteorological Diary for the Months of January and February, 1816, kept at Earl Spencer's Seat at Althorp, in Northamptonshire. The Thermometer hangs in a north-eastern aspect, about five feet from the ground, and a foot from the wall.

METEOROLOGICAL DIARY

for January, 1816.

		Thermometer.		Barometer.		Wind.	
		Low.	High.	Morn.	Even.	Morn.	Even.
Monday	1	31,5	40	30,34	30,30	WSW	WbS
Tuesday	2	24,5	35	30,17	30,03	W	W
Wednesday	3	32	39	30	30,11	NW	WNW
Thursday	4	27	36	30,28	30,23	W	W
Friday	5	33	43	30,08	30,06	W	W
Saturday	6	36	49	29,74	29,61	SW	W
Sunday	7	33,5	39	29,77	29,87	W	WNW
Monday	8	33	49	29,55	29,30	WSW	WSW
Tuesday	9	41	47	29,37	29,43	W	SSW
Wednesday	10	39	45	29,31	29,32	W	W
Thursday	11	42	46	28,86	28,95	W	W
Friday	12	35	41,5	29,35	29,09	W	SW
Saturday	13	40	43	28,92	28,88	SW	SW
Sunday	14	32,5	40	29,15	29,30	SE	ESE
Monday	15	28	40,5	29,22	29,10	ESE	SSW
Tuesday	16	34	40	29,50	29,59	W	WSW
Wednesday	17	34,5	38	29,31	29,41	W	W
Thursday	18	30,5	39	29,54	29,54	W	SSW
Friday	19	22	37	29,59	29,55	S	SSE
Saturday	20	30	35	29,42	29,34	W	SSW
Sunday	21	29	39	29,11	29,11	E	ESE
Monday	22	38	42	29,29	29,35	E	EbS
Tuesday	23	35	40	29,38	29,29	SE	ESE
Wednesday	24	36	38	29,17	29,10	EbS	E
Thursday	25	32,5	36	29,03	29,02	E	NE
Friday	26	33,5	40	29,12	29,25	NE	NW
Saturday	27	34	38	29,47	29,77	N	NNE
Sunday	28	30	36	29,96	30,05	NNE	NNW
Monday	29	19	31	30,19	30,19	NNW	NNE
Tuesday	30	16	30,5	30,25	30,24	E	S
Wednesday	31	17,5	32	30,15	29,99	S	S

METEOROLOGICAL DIARY

for February, 1816.

		Thermometer.		Barometer.		Wind.	
		Low.	High.	Morn.	Even.	Morn.	Even.
Thursday	1	16	32,5	29,80	29,68	SE	S
Friday	2	15	36	29,53	29,39	S	SE
Saturday	3	34	44	29,30	29,30	W	WSW
Sunday	4	33	43,5	29,30	29,28	SW	W
Monday	5	30	39	29,30	29,27	W	W
Tuesday	6	34	35	29,09	28,95	NE	NE
Wednesday	7	28	31	28,88	29,07	NE	N
Thursday	8	17	27	29,21	29,40	N	N
Friday	9	−4	23	29,45	29,48	NNW	EbS
Saturday	10	−2,75	30,5	29,50	29,50	EbS	S
Sunday	11	20	35	29,65	29,83	W	NNW
Monday	12	15,5	30,5	30,08	30,16	WbN	W
Tuesday	13	19	37	30,16	30,10	WSW	WbS
Wednesday	14	27	37	30,13	30,18	W	W
Thursday	15	29	41	30,19	30,09	W	W
Friday	16	36	47	29,88	29,62	W	NW
Saturday	17	31,5	37	29,70	29,79	WNW	NNW
Sunday	18	24,5	39	29,93	29,70	WNW	W
Monday	19	38	44	29,76	29,81	W	WbW
Tuesday	20	32	47,5	29,81	29,73	WSW	SW
Wednesday	21	30	45	29,87	29,91	W	NW
Thursday	22	29	48	29,91	29,93	SW	SSW
Friday	23	38	49	30,02	30,09	W	S
Saturday	24	28	51	29,99	29,91	SW	SW
Sunday	25	36	51	29,80	29,64	SW	W
Monday	26	31,5	43,5	29,88	30	W	W
Tuesday	27	28	51	29,70	29,40	WSW	W
Wednesday	28	31,5	40	29,60	29,75	N	N
Thursday	29	22	37	29,80	29,75	NW	W

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// THE QUARTERLY JOURNAL

OF

SCIENCE AND THE ARTS.

Art. I. *On the Laws of Sensation; with a prefatory View of the present State of Physiology. By* T. R. Park, *M. B. F. L. S.*

The imperfect state of our knowledge of the animal economy is a point so generally known and admitted, as to require little illustration or argument.

If, however, an enumeration of the problems which physiology is avowedly unable to explain be not required, in order to vindicate the necessity for a revision of its principles; it may, at least, serve to convey an idea of the subjects treated of in the present and subsequent papers on this branch of science.

Among the first, and simplest phenomena of life, we may rank sensation, one of those primary attributes which distinguish animal from other organised matter: and upon which most of the living functions will be found to depend.

The questions that remain unanswered respecting the nature of this faculty, its varieties and modifications, and the occasional fluctuations it undergoes, are numerous and important.

One part of the body is endowed with sensibility in an eminent, another in a slight degree; and parts of little sensibility are liable at times to become exquisitely painful; while those eminently endowed with it, experience occasionally a diminution, or loss of that faculty. Different parts of the body vary also in their kind, as well as degree of feeling, each having a mode of sensation which no other is ever known to experi-

ence; thus the sense of lassitude is confined to the muscles, aching to the bones, itching to the surface.

The effects that result from these sensations are equally curious and interesting, and must also be classed with those which physiology has not hitherto been able to explain. Thus, every cause that excites sensation, if sufficiently permanent or powerful in its impression, produces a change of condition in the part that receives it, which becomes red or painful. Impressions made on one part often produce change of condition in another: thus, any thing hot or spicy taken into the stomach causes a glow and redness in the face.

The terms irritation and sympathy, commonly employed to explain these effects, are justly regarded by the best physiologists as a mere subterfuge for ignorance.

While the influence of corporeal impressions remains unexplained, that of mental emotions is still less likely to be understood. Thus, why fear drives the blood from the face; why grief interrupts respiration, causing sighs and tears; why conscious guilt, or the apprehension of seeming guilty, brings the blood into the face, are points generally allowed to be inexplicable.

Another of the primary attributes of life is motion, upon the exertion of which the performance of every vital function immediately depends. Circulation, respiration, and digestion, as well as the faculty of speech and the exertion of our limbs, are all performed by muscular fibres.

The attemps made to explain the nature of muscular motion with its varieties and occasional fluctuations, betray the infant state of our knowledge, as much as the attempts to account for the phenomena of sensation.

One class of moving fibres is known to possess a high degree of mobility, or an extensive range of action, but is incapable of enduring a state of permanent contraction; while another can endure a state of permanent contraction for many hours, but is very limited in its range of action, or has a small share of mobility.

These different properties of moving fibres have never been diligently traced out, nor the relative powers of each

carefully ascertained. The successive stages of action, or the gradual changes which the powers of motion undergo during continued exertion, and which eventually lead to that state of painful exertion called fatigue, have not been duly considered. The nature and cause of fatigue are not yet accounted for; nor has the degree in which different organs are liable to experience it, been yet determined.

In short, the laws of motion still remain to be ascertained as much as those of sensation; although upon the knowledge of them depends the explanation of many of the most important phenomena of life; such as the periodical returns of hunger and thirst, sleep and waking, and all the diurnal fluctuations which the faculties of the mind and the powers of the body are observed to undergo. Certain limits are affixed to the powers of every moving fibre: the stomach and intestines, the heart and blood-vessels, having their stated periods of action, and of comparative rest, as well as the limbs. This, as will be shewn, occasions the continual changes of action which the organs of circulation exhibit; and their fluctuation involves that of every function dependant upon circulation.

Such is the state of our knowledge with respect to the first and simplest phenomena of life; and that we cannot satisfactorily explain the derangement of any function, while we remain partially ignorant of the nature of the function itself; or account for the operation of remedies in removing a disease, while the true nature of the disease is unknown, seems an almost self-evident proposition.

This then at once bespeaks both the importance of physiological inquiries, and the order in which they ought to be pursued. But previously to entering upon the subject, a more particular account of the progressive and present state of the science seems called for, which the following concise sketch may serve to convey.

If we revert to distant periods, we find the science of physiology bearing always the stamp and character of each particular age, advancing or receding with the general state of philosophy.

In the early stages of society, medicine appears to have been

confined to the priests; and, accordingly, the phenomena of disease were referred to supernatural agency; and the practice of physic consisted chiefly of superstitious rites.

As philosophy began to engage the attention of man, the science of medicine also partook of the changes introduced. The metaphysical refinements of the Pythagorean School at one time perverted the judgment: At another, the logical subtlety of the Aristotelian diverted the attention from the proper objects of research, and from the careful observance of nature: Next arose the Empirical Sect, who denied the utility of reasoning in medical science; and well might the advantage of a mode of reasoning, such as then prevailed, be called in question.

The Arabians, who derived their knowledge chiefly from the Greeks, introduced chemistry into medicine, and in the dark ages magic and astrology were blended with the practice of physic.

At the revival of learning in the 15th century, an important era presents itself. The rapid progress of all the arts and sciences, naturally produced a change in that of physiology. The improvements in mechanics and mathematics afforded the brightest prospect of its rapid advancement.

But, instead of adopting the mode of reasoning so beneficial in the one, or exerting the ingenuity so successfully employed in the other, the sciences themselves were blended together. Mechanical principles were applied to explain vital phenomena; and mathematical reasonings and language were introduced into physiological writings.

The influence of the sentient principle was too little regarded among the disciples of the mechanical and mathematical schools; but shortly after began to engross too large a share of attention, as the mind naturally fluctuates between extremes; and almost every derangement of function was now ascribed to an effort of nature to relieve herself from some noxious cause.

The science, however, continued to gain a fresh accession of facts, and became enriched by more judicious observations. The insensible perspiration discovered by Sanctorius, the

circulation of the blood by Harvey, and the absorption of nutritive matter from the intestines, by the class of vessels termed lacteals by Pitcairn, were among the fruits of the 17th century.

During the 18th, the anatomical researches of the celebrated Haller contributed materially to increase our knowlege, while our views were enlarged by the sound reasoning of Whytt, the ardent genius and indefatigable industry of Hunter; and the creative fancy of Darwin scattered new lights, though unrestrained by the strict rules of philosophy.

To these might be added many others, who have enriched physiology by their labours; but still its progress was not co-equal with that of some other branches of science, nor commensurate with the talent employed in its cultivation.

Within these few years, the spirit of enquiry which had been for some time nearly extinguished, has been re-kindled by the celebrated French physiologist Bichât, who, shaking off the trammels of authority, has dared to question the truth of received dogmata, and loudly proclaimed the necessity for establishing the science on a new foundation.

As his writings contain many recent improvements, a brief outline of his views, with a short critique on his system, will convey a pretty accurate idea of the present state of our knowledge of the animal economy.

Bichât divides the functions of the living body into two classes; one of which he terms *animal*, and the other *organic*, or *automatic*.

Animal functions, are those which regard man's connection with the objects around him, by which he hears, sees, feels, moves, and thinks, expresses by voice his hopes and fears, his pains and pleasures; in short, those faculties which render him an inhabitant of the world at large, and do not, like the attributes of vegetable life, circumscribe the sphere of his existence within the limits of the spot which gave him birth.

Organic functions, on the other hand, are those which have relation only to his own internal economy; which administer to the nourishment and support of his body; such as nutrition, circulation, respiration; functions enjoyed by all organised

matter in common with man, even by vegetables as well as animals; having no relation to man's intercourse with the world at large, but confined to his own individual existence.

This is his first grand division of the functions; the next subdivides each class into two orders.

In animal functions one order enables him to receive the impressions and take cognizance of the existence of surrounding objects; and the other enables him to exert his influence over them, converting them to his use or making them subservient to his enjoyment.

In organic functions, one order enables him to assimilate to his body and appropriate to his own nourishment and support the materials on which he feeds; and the other enables him to separate and reject from his system what is no longer useful or necessary.

The brain is the central or primary organ in animal functions, which receives, through the medium of the nerves, cognizance of all impressions made upon the body; and through the same medium communicates to the organs of motion the impulse of the will, enabling it by their intervention to re-act upon external objects. The brain is, therefore, the common centre of animal life.

The heart is the primary organ of automatic functions, to which all the materials of nutrition are conveyed by means of the blood-vessels, as soon as properly assimilated,—and from which they are sent back also through the medium of vessels, and dispersed over all parts of the body for its nourishment and support.

The heart and blood-vessels stand therefore in the same relation to assimilating functions, that the brain and nerves do to the perception of external objects, and man's influence in re-acting upon them.

Such is the basis of Bichât's classification.

The accuracy of this distinction, and the expediency of adopting his system must be determined by a critical examination of the principles on which it is founded. Bichât conceives that there are distinguishing peculiarities between the two classes of functions sufficient to establish a radical and funda-

mental difference in their nature. He does not propose his system as an arbitrary arrangement, but contends that there are natural limits which mark the boundary of each class in a manner perfectly definite and precise. These are the grounds of his distinction.

1st. The two classes differ in the form and structure of their organs.

2dly, They differ in their mode of action.

3rdly, They differ in the durability of their action.

4thly, As to the influence which habit exerts upon them.

5thly, As to moral influence or the share the mind has in their performance.

6thly, As to the nature and source of their vital powers.

7thly and lastly, They differ as to their developement and final termination.

To return, the first difference is in point of form between the organs of animal and automatic life. The organs of animal life are all double—the eyes, the ears, the nose, the organs of voice, those of voluntary motion, the limbs, are all two-fold, and perfect similarity prevails between the opposite sides of the body. The brain also, or organ of mind, is composed of two hemispheres, and a vertical line might be drawn so as to divide the body into two equal halves, each of which, though incapable of separate existence, might in other respects be regarded as a distinct and entire animal.

In organic life the organs are either single, as the heart, the stomach, the intestines, the liver, the spleen, the pancreas: or if two-fold, as the lungs, the salivary glands, and the kidneys; they want that symmetry of form observable in the organs of animal life.

The next point of distinction regards the mode of action.

In animal life the due performance of the function requires perfect unison between the opposite sides; thus if half the body be paralysed, the power of locomotion is lost; if one eye be weaker than the other, vision is rendered indistinct; or if one ear be more sensible to sound, the function of hearing is disturbed by this want of consonance of action.

In organic life it is otherwise, one half of the lungs, one

kidney, or the salivary glands of one side may have their function deranged, while that of the other is unimpaired by it.

The next is a more important point of distinction, relating to continuity of action:

The organs of animal life are subject to stated intermissions of action; thus the exertion of our limbs and the powers of our minds require the periodical return of rest and sleep to support and restore them: but,

The functions of organic life are stated to continue without intermission or fatigue; thus respiration, circulation, secretion, and absorption are never suspended, but continue uninterrupted from the commencement of life to its termination—from the cradle to the grave.

Further, They differ as to the power of habit and education. The influence of habit is required to improve and cultivate the functions of animal life. In respect to the powers of mind, locomotion, and speech, man is, in great measure, the creature of habit and education; but,

Habit is stated to have no influence over the functions of organic life; respiration, circulation, digestion being performed by the infant as perfectly as by the adult.

The two classes differ also in regard to the moral influence, or the share which the mind has in their performance.

The motions of our limbs and those which belong to animal functions are under the complete dominion of the will; may be increased or diminished, suspended or resumed at pleasure; but,

The actions of the heart, stomach, and intestines, are governed by fixed and determinate laws, wholly exempt from the controul of the will, which has no power to suspend or alter them.

When an impression is received by the organs of sense, a change is propagated to the sensorium, the mind becomes sensible of it, and can exert the means it possesses to remove the cause, if the impression be displeasing.

When an impression is made upon the organs of automatic life the change it exerts is not transmitted to the brain, but confined to the organ that receives it—the mind remaining inconscious of the effect it produces. The heart, stomach, and

intestines are sensible to the impressions they receive, and their actions correspond to them, but the mind takes no cognizance of the changes going on.

Further, Bichât conceives the two classes to differ in respect to the nature of their vital powers, and the source whence they are derived.

In animal life he considers nerves as the agents employed in receiving and transmitting impressions to the brain:—whereas in organic life he regards it as at least doubtful, whether nerves be at all instrumental to the production of sensation.

In like manner with respect to motion, he considers nerves as the immediate agents in producing voluntary contraction, but he questions their being essential to the production of that which is involuntary.

Lastly, they differ in regard to the periods of their developement and termination.

The organic functions, as circulation, assimilation, and excretion, commence from the first moment of conception.

The animal functions, on the other hand, as locomotion and mind, are not developed till after birth, and then are long in arriving at maturity.

The period of their natural termination is also different, as well as that of their commencement. As old age approaches the faculties of mind are enfeebled, the powers of locomotion and speech begin to decline, and in extreme old age man almost returns in these respects to the same state with which his existence commenced.

But the powers of organic life, as the action of the heart, the stomach, and intestines, which are independent of the sensorium, often continue for a considerable period after those of animal life are nearly extinct; and in natural death the last organ that ceases to act is the first which began, namely the heart, the source, the centre of organic life.

Such is the nature of Bichât's classification of the functions, and such the grounds on which he conceives it to be established, that animal and organic life are essentially different, and although intimately connected, yet so far distinct and independant, that he ascribes them to separate vital principles.

This arrangement is certainly ingenious and beautiful, and may prove, in many respects, useful, if admitted as an arbitrary distinction; but if minutely examined, it will appear, besides some inconsistencies which it involves, that every point of distinction has been strained to make the contrast more striking, and we must allow that nothing can be strictly philosophical which is not strictly true.

When the love of generalization leads us astray from the accurate observance of nature, and tempts us to distort facts to make them accord with our views, the end of classification is defeated, and the best interests of science are sacrificed to the support of system.

There are indeed two objects in classification, one is to assist the memory by methodical arrangement of the phenomena; and the other to ascertain the principles by which they are governed. The former is an arrangement of facts, the latter an investigation of causes.

The same rigid accuracy is not required in both; the memory may be assisted by a classification which admits of many exceptions: but the laws of nature admit no exception, however their effects may be varied or modified.

It is only as an arbitrary arrangement that Bichât's system can be received, and even then with some slight modification hereafter to be explained. But if the principles on which it is founded are to be regarded as fundamental laws in physiology their accuracy must be disputed in almost every particular.

The grounds of this dissent will be fully detailed in the sequel; a few general remarks upon it will be sufficient at present. Considered as a mere classification it is in some points most singularly at variance with itself; thus Bichât ascribes the sensations to animal life, but the passions and all that relates to them, he refers wholly to organic life.

How does this accord with his own definition of the classes? Organic functions are those which are essential to the nourishment and support of the body, which are enjoyed by vegetables as well as animals.

Have vegetables passions? Has the fœtus in utero? Are they subservient or essential to the nourishment and growth

of the body, or are they not exclusively the attributes of animal life; those very feelings which establish man's connection with external objects, and make him an inhabitant of the world at large? This must certainly be admitted as a glaring inconsistency in the arrangement itself.

The objections to the principles which this system is intended to establish are in a physiological point of view still more important.

Bichât lays down as a fundamental law, that the state of rest is confined to the organs of mind and voluntary motion, while the involuntary organs are stated to experience no intermission of action, and to have no periods of relaxation or rest.

When we come to examine the grounds of this conclusion, we shall find that it rests upon a foundation much too loose to be admitted.

Involuntary, do not indeed like voluntary organs, excite the same sensation of fatigue from long continued exertion, but we shall find that muscular action is productive of the same changes in all moving fibres, all having their powers of action limited, and requiring a degree of rest, proportioned to their previous exertion.

Sleep is regarded by Bichât, in common with other physiological writers, as an affection confined to the organs of voluntary motion and mind. Yet they all concur in assigning as its physical cause some change of circulation in the brain.

Now circulation is an involuntary function, and if sleep therefore originate in altered circulation of the brain, then it is primarily an affection of involuntary organs in which the voluntary organs indirectly participate.

Voluntary motion is ascribed by Bichât to influence of nerves, but he denies or doubts their instrumentality in the production of that which is involuntary. Here again his judgment is evidently warped by the love of generalization, and the very experiments he adduces in support of his opinion will be found sufficient for its refutation.

He maintains also that there are two kinds of sensation, one attended with consciousness in the mind and the other not. The former he ascribes to nervous influence, but denies this

influence in the latter. Here again we must dissent from him; and if the power of exciting consciousness be communicated through nervous influence, all parts must have nerves, for all at times manifest this power.

As a more detailed account of particular doctrines and the opinions of different writers must necessarily be given in discussing each separate branch of the subject, the preceding sketch appears sufficient for the purpose at present intended, which is merely to offer a general view of the state of the Science.

Proceeding then to the doctrine of Sensation,

The first question for consideration is the nature and cause of this faculty.—

Sensation is evidently an effect that results in part from physical and in part from vital influence.

A physical agent is applied to our bodily organ; a change is thereby produced in the sentient extremities of the nerves, and the feeling that results from or attends this change constitutes sensation.

The effect is physical in so far as the operation of a physical agent is required to produce it.

It is vital in so far as this agent can no longer produce sensation when the body is dead.

Resulting then from the joint influence of two distinct causes, physical agency, and vital susceptibility—its phenomena must be governed by the operation of laws partly physical and partly vital.

These laws it is our business then to ascertain. There is one source of fallacy connected with the doctrine of sensation which must be guarded against.

In the language of common life we never employ the term Sensation but with reference to that mode of feeling which is attended with reflex consciousness in the mind, or to express those feelings which are thought of and reflected upon.

But the language of common life is often too vague and indefinite for scientific enquiry, and physiologists being constrained to admit that there are sensations which do not excite our attention or awaken mental perception, have employed different modes of expression to avoid misapprehension.

Dr. Whytt for this purpose made use of the circumlocution of sensation *with* or *without* reflex consciousness.

Bichât adopted another expression, and called one *animal* the other *organic*, sensation.

It is of little moment what terms we employ to express this distinction, but it is of the first importance that we have a clear conception of the doctrine which calls for its employment.

Dr. Whytt (in his admirable treatise on the vital and involuntary motions,) contended that they all proceed from impressions perceived by the mind, but that the mind can experience sensation, without reflecting upon it; and excite correspondent actions without thinking of them.

In this way he conceived respiration to be carried on while we are asleep, and in like manner he regarded the action of the heart and arteries, that of the stomach and intestines as proceeding from impressions on their nerves felt and corresponded to, but not reflected upon, by the mind.

Bichât has slightly modified this doctrine of Whytt, allowing the existence of this mode of simple sensation, but denying that it is a mental operation or proceeds from the brain. He contends that it is possessed by every separate organ even when taken out of the body, and by the fœtus in utero, but he denies that in these cases there can possibly be any mentâl operation connected with it, such as consciousness or volition, reason or reflexion.

These are effects which he refers exclusively to the brain, as the immediate organ of mind.

Now although there may be some slight difference in these views, yet both agree in the main point that sensation and reflexion are distinct faculties capable of being separately exerted.

The nature of this unreflected sensation must ever elude our conception, since it cannot become an object of experience, but we may admit its existence, though we remain ignorant of its nature and mode of operation, and the following experiments seem sufficient to establish the existence of unreflected sensation.

The body of a frog is found by experiment for hours after its

head has been cut off, to draw in its leg when pricked in the foot, to jump away if wounded in the body; and to struggle till it recovers its natural position, if laid upon its back; all these appear to be effects that denote the existence of something analogous to sensation in the headless trunk, though no doubt destitute of the reflex consciousness that would have directed the operation of the animal before its head was cut off.

As it would then seem that the headless trunk of the frog yet possesses, while warm, some share of vitality, and a faculty of unreflected sensation, to which it still owes the exertion of such motions as are rendered spontaneous by habit, and require no reflection or volition; so we may conceive that a similar mode of feeling supports respiration when we are asleep; occasions the heart, stomach, and intestines to contract upon irritation, and excites every organ to action which is not subject to the controul of the will.

Vital phenomena we may consider them, but, on the other hand, we should regard them as distinct from mental operations, and not the result of a power proceeding from the brain; since they continue to be exerted when the brain is separated from the body, in an amputated limb, and in the heart when taken out of the chest, so long as the vital warmth is retained.

Nerves are shewn to be the intermediate agents by which the mind is rendered conscious of the sensations excited in distant parts, by the familiar experiment of dividing them, or interrupting their communication with the brain, whereby the mind loses all consciousness of the impressions made below the interruption. Thus the brain appears to be the seat of consciousness, and the nerves the agents in transmitting the change which awakens reflection. But as the part below the division of the nerve still remains sensible to irritation it appears that the nerve alone is still capable of experiencing unreflected sensation: or, according to the views of Dr. Kirkland, nerves should be considered as prolongations of the brain, possessing, when detached from it, vital powers different in degree, but analogous in their nature, and retaining these powers while the vital warmth continues.

In this way then we may modify the doctrines of Whytt and

Bichât, allowing with Whytt the existence of simple abstract sensation, but not regarding it as a mental operation, or as proceeding from the brain. With Bichât we may also admit that sensation may or may not be accompanied by reflection; but still we should consider sensation as essentially the same faculty, whether it be followed by reflexion or not.

Sensation is still the function of nerves: Reflection that of the brain: and each may occur separately, or both may be conjoined, as in the ordinary acceptation of the term.

Regarding then sensation as the exclusive attribute of nerves, we shall now attempt to trace out the laws by which its phenomena are governed, and endeavour to shew what share of them is to be attributed to physical agency, and what is due to vital influence.

A physical cause is applied to some part of the body, and produces a change which is attended with feeling, and this feeling constitutes sensation.

The first requisite then is the production of some physical change in the condition of the organ to excite sensation, which in so far is subject to physical laws.

We have abundant evidence of this in the fact that every substance, producing a different change, occasions a different sensation--the effect produced always according with the nature of the substance applied. And the properties of matter being uniform, the same substance produces always the same changes. Hence sugar is always sweet, lemon acid, and quassia bitter; though the organ may not always be in the same condition to perceive these changes; the change is uniform—the sensibility may vary.

The share which physical agency has in producing sensation has, however, been disputed by Darwin, who contends that sensations are not the perception of physical change in the organs, but consist in motions of the nervous fibres, "To determine that the retina and other organs of sense possess a power of motion, and that these motions constitute our ideas, claims our first attention."—*Zoonomia,* vol. i. p. 16, sec. 3. i. For illustration he selects the following instance:

When the eye is fixed on a black spot in the centre of a white

ground, and after looking at it steadfastly for some time, turned aside to the white surface a spot will appear, brighter than the rest of the ground, corresponding in shape and size to the black one before looked at.

Now Darwin infers from this, that our idea of light is not the perception of changes induced, or impressions made on the rétina by light as a physical agent; but consists in motions or fibrous contractions excited in the nerve. And thus he reasons :—

If the idea of light arise from changes induced on the retina, "they must either continue as they were received, or not continue at all." That is, a black spot must still be perceived when the eye is turned aside to the white ground, or no spot at all.

The fallacy of Darwin's objection rests upon this; that he confounds the changes that have been made, with those actually going on. It is the changes actually taking place that excite sensation, and not those that have already past.

Let us now suppose, that vision consists in the perception of changes going on from the physical action of light on the retina, and see what follows.

Every part of the retina, except that directly opposed to the black spot, will soon have undergone those changes which the light reflected from the white surface is capable of producing; and as the same changes cannot be again induced in exactly the same degree before the former impression is in some measure obliterated, the organ will have partially lost its susceptibility, or that part will be rendered less capable of undergoing similar changes, until the vital energy has restored it to the natural state, and may thus for a few seconds be incapable of exciting the sensations arising from the impression of light.

But that part of the retina opposed to the dark spot, not having undergone these changes in an equal degree, will retain a higher degree of susceptibility; and when the eye is turned aside, and all parts equally exposed to the impression of the light reflected from the white ground, they will be differently affected by it: this spot will excite a stronger perception of light, or appear comparatively luminous, and the rest relatively darker.

Darwin's inference is therefore unwarranted; so far, at least, as it applies to the necessity for physical changes in the organ to excite sensation.

In what manner these changes are propagated along the nerves, until they reach the sensorium, and excite reflex consciousness in the mind, is a distinct proposition.

If this be accomplished as Darwin contended, through the means of fibrous contractions in the nerves, still these fibrous contractions cannot be said to constitute our ideas, any more than the physical changes in the sentient organ constitute our sensations.

These fibrous contractions propagated to the brain, may be supposed to excite reflection or consciousness in the mind in the same way that physical changes in the organs of sense excite our sensation. The physical changes are not sensation; nor are the fibrous contractions reflection; they may be their exciting cause.

Admitting then the necessity for physical agency, let us endeavour to trace out its limits, and ascertain the extent of its operation.

The physical changes produced may be either mechanical or chemical.

Mere mechanical agents do not combine with our organs, and leave therefore a less durable impression, which ceases soon after the cause is removed.

Thus light, if we may consider it to act by mechanical impulse, impinges upon the retina of the eye, and the change induced excites the sensation of vision. The motion of the air beating on the drum of the ear, causes vibrations which give rise to the sensation of sound. Substances applied to the membrane lining the nose or mouth, which have no chemical action on the fluids, produce no sensations of smell or taste, as sand, when taken into the mouth, has no taste, but causes merely a mechanical impression. In the same way impressions on the organ of touch, accordingly as they are rough or smooth, hard or soft, excite the corresponding sensations, which take their name from these properties.

Chemical agents, on the contrary, are more durable in their

impression, as they are dissolved iu the fluids on the sentient surface and require more time for the changes they produce to be again obliterated; and accordingly, until this has been effected, the organ may be regarded as having its susceptibility for that particular impression partially suspended; or the substance applied, no longer producing the same change, no longer excites the same sensation: thus substances kept long applied to our organs of taste lose their power of exciting sensible impression, as wine long held in the mouth loses the flavour peculiar to it; and if several kinds of wine be tasted in quick succession, it soon becomes difficult, or impossible to distinguish them.

Although one substance may for a time have lost its influence, yet another may be capable of exciting sensation.

It is even reasonable to suppose that the action of one substance may in some cases tend to efface or counteract the changes produced by another exciting changes of an opposite nature: and we accordingly find that a change of impression frequently helps to restore the sensibility of the organ. Thus when the application of opium has suspended for a time the susceptibility of impression, the use of acids is found to counteract this effect, and assist in restoring the faculty of sensation.

Experience teaches us that the habitual use of strong stimulants may impair in time the sensibility of our organs, an effect also referable to physical laws.

As every perception is preceded by a transient physical change, it is easy to conceive that the frequent repetition of these changes may in time permanently alter the texture of the part, as the texture of the mucous membrane becomes altered from exposure to the air, and as the hands grow rough from hard labour. And in the same manner the sentient surface loses its delicacy, aud becomes less susceptible of the impressions it receives.

As sensation arises from a physical change in the sentient organ, it also follows that the more delicate the texture of the organ, the more it will be susceptible of change: the soft and flaccid fibre should therefore more readily experience the effects

of physical agency, than the dense and rigid. And we accordingly find, that infancy and youth are characterised by a higher degree of susceptibility than manhood or old age.

The same view explains an important principle in pathology; why weakness and loss of tone render the body more susceptible of noxious impressions : thus want of exercise, unwholesome food, confined air, depressing passions, and other debilitating causes, are enumerated among those which promote the influence of contagion.

The various kinds and degrees of sensation which arise from the application of different substances to our organs, may be referred to their peculiar modes of action ; and accordingly they are as various as the nature of the substances.

As some are quick, others slow, some feeble, others powerful, some transient, others permanent, in their operation ; we may presume that the more rapid the change, the more vivid will be the sensation : or the degree of feeling will be determined by the rapidity with which the change is produced, and the kind of feeling by the nature of the change.

Such appears to be the nature of physical influence, and the share it has in producing sensation. We have now to turn our attention to the other branch of the subject, or the share which vital influence has in its production.

As far as the phenomena depend upon physical influence they are subject to but little variation, the properties of matter being constant and uniform ; but that share of them which results from vital influence is liable to considerable fluctuation, as the vital powers are frequently varying.

One part of the body differs from another, not only in its susceptibility of impression, but likewise in its capability of exciting attention or consciousness in the mind, or they vary in relation to their sensitive, and also their perceptive faculty.

These are points that require to be separately considered.

The sensitive and perceptive power bear often so little relation to each other, that the same part possesses the former in a very eminent, and the latter in a very slight degree. Thus the internal surface, which is highly sensitive, as the action of medicines declares, has very little power of awakening

perception in the mind of the impressions it receives; while on the other hand, the external surface, which is most capable of exciting the attention of the mind, is comparatively insensible to medicinal impressions. Even the brain itself is far from being a sensitive organ, as experimentally proved when it has been touched or irritated.

The brain being the seat of reflection, or the organ of consciousness, the degree in which any part participates in this faculty, is proportioned to the intimacy of its connection, or communication with the sensorium, through the medium of its nerves, as stated by Bichât and others.

The organs of sense, and the external surface, derive most of their nerves directly from the sensorium; and the mind therefore most readily takes cognizance of the impressions made upon them.

But the internal surface and the viscera derive the largest portion of their nerves from the gangliac system; or the communication of those parts with the brain is most frequently interrupted by those knots, or enlargements, termed ganglia, which Bichât and other eminent physiologists suppose, with apparent reason, to impede, in a certain degree, the transmission of change produced at the sentient extremities. Accordingly, the degree in which each organ participates in this power of exciting consciousness, will be found to bear a pretty uniform relation to the intimacy of its nervous connection with the sensorium.

The various degrees in which different parts are endowed with the sentient faculty is a question not less interesting, and the circumstances connected with it merit the most particular attention. Of these the following appears to be the most remarkable.

A circumstance peculiar to all parts endowed with the sensitive faculty in an eminent degree is, that they are all abundantly supplied with vessels carrying red blood.

Thus the skin has beneath its cuticle a supply of blood to its sentient papillæ from the vessels of the rete mucosum.

The mucous membrane more highly sensitive still, with a thinner cuticle, has a more ample supply of red blood.

This membrane constitutes the immediate organs of taste and smell, as well as a covering to the whole internal surface, which shews, in the effect of medicines, its superior susceptibility to that of the skin.

The same abundant supply is found also in other sensitive parts; thus the retina of the eye is expanded over the vascular membrane, called the choroid; and the auditory nerves have the pulpy vascular membrane in the cavities of the ear; and thus an ample supply of red blood appears to be one of the conditions requisite to a high degree of sensibility.

On the other hand, those parts which are devoid of sensibility, appear to be comparatively destitute of red blood.

Thus the cellular membrane covering the muscles, and investing each separate muscular fibre, the serous membrane surrounding the viscera, and lining the cavities that contain them, the fasciæ or fibrous membranes in different parts of the body; the periosteum covering the bones ligaments and tendons, are almost exclusively supplied with vessels carrying only serum or lymph, and are in the healthy state nearly insensible.

Thus there appears some connection between sentient power and the supply of red blood. But this is not all; different parts not only vary in their degree of sensibility, but the same part varies at different times; and the connection between circulation and sentient power becomes still more striking as we proceed in the examination, and find that this power fluctuates with every change the circulation undergoes, increasing within certain limits as circulation increases, and decreasing as circulation diminishes; and parts which in the natural state of circulation are not endowed with sensitive power, become highly sensitive in a state of morbid circulation.

The following instances may illustrate this principle, and shew the influence of diminished and of increased circulation.

Every cause that diminishes the afflux of red blood to the surface, produces a corresponding diminution in its susceptibility of impression: thus the retarded circulation and shrinking of the capillary vessels that arises from inaction so deadens the sense of feeling, that the fingers in writing will be scarcely able to feel the pen.

The same effect attends the chillness produced by nervous apprehension, which at times so benumbs the sense of touch, as to deprive a timid musician of the power of playing.

The effects of external cold are familiar to every one, destroying the power of discriminating between different impressions, and therefore impairing susceptibility, although often productive of considerable pain in the part affected. In extreme cold the extremities have been known to drop off without being felt. The pain in parts that have been frozen occurs when the circulation is restored again. The impeded circulation attending febrile affections shews the same diminution of the sentient faculty; thus all the feelings are blunted in the cold fit of an ague.

Causes that increase circulation, on the contrary, increase the sensitive faculty; thus, in any work that requires nicety of touch, if the weather be cold, we naturally hold our hands to the fire, or rub them to promote circulation. The increased circulation produced by exercise often causes the surface to become sensible to impressions unnoticed before; thus a flannel waistcoat, or woollen stockings, in persons unused to wear them, excite intolerable itching as soon as they grow warm. As the sense of feeling is impaired in the cold fit of ague, so it is morbidly increased in the hot fit.

This change is still more remarkable in local inflammation, rendering the eye so sensible, that the ordinary impression of light is not to be borne; or causing the least noise to be painful from morbid sensibility of the ear; and other effects similar in their nature, and familiar to every one.

This law establishing the relation that obtains between the circulation of an organ and the state of its sentient faculty, is one of the most extensive and important in the science of physiology, and singular it must appear that it should so long have been disregarded.

It is subject, however, to modification, from two causes, viz. from the nature of the organ affected, and the function it has to perform.

As every organ possesses, in its natural state, that degree of susceptibility which is best adapted to its function, increase

of susceptibility is not necessarily attended with augmentation of function; on the contrary, every deviation from the natural standard must appertain more or less to the nature of a derangement.

Thus morbid circulation of the brain causing morbid susceptibility, produces insanity.

If the eye be rendered too sensible to light, vision is not improved but disturbed by it.

If the ear be morbidly sensible, confusion of sounds may be the result.

If the nose or mouth be inflamed their surface becomes dry, and their peculiar sensibility suspended for want of the moisture required to favour the action of saporous bodies or odoriferous particles.

Such are the modifications of the principle arising from the function of the organ.

With respect to structure, a further modification of this principle occurs, presenting sometimes results which at first appear rather paradoxical: thus,

The parts most painful under inflammatory circulation are not those which are most sensible in health, but on the contrary those which are least so.

The mucous membrane, forming a part of the organ of smell, and therefore highly sensitive in health, is far from painful when inflamed, as in colds or catarrhal affections.

Other parts of this membrane, as those lining the fauces, the œsophagus, the stomach and intestines are also subject to a similar change of circulation, or what is called erythematic inflammation; this being the most probable cause of the affections called heart-burn or cardialgia, indigestion or dyspepsia, diarrhea, &c. none of which are attended with much pain or uneasiness.

The serous membranes, on the contrary, which are devoid of sensibility in the healthy state, become exquisitely painful under inflammatory circulation. Thus pleurisy, or inflammation of the membrane investing the lungs; gastritis or enteritis, inflammation of the membrane covering the stomach

and intestines, and all other affections of this class are most acutely painful.

In like manner the fibrous membranes or fasciæ, insensible in health, become exquisitely painful when inflamed, as in whitlow of the finger; the ligaments and tendons also, nearly insensible in health, are acutely sensible under inflammation, as in gout and acute rheumatism; also the periosteum or covering of the bone becomes intolerably painful in nodes, which in health is nearly or entirely destitute of feeling.

For the solution of this paradox we must look to the nature of sensation on the one hand, and to that of inflammatory circulation on the other.

Sensation is the perception of changes going on in the part, and the greater the change, the greater the pain.

The difference between the natural and the inflammatory circulation is this, that all those parts which are insensible in health circulate only serum, while those which are sensible circulate red blood; but when they become inflamed, red blood is transfused through all, both serous and sanguiferous vessels being gorged and overdistended with it.

The change then which is produced must needs be greater in those parts where the natural is most remote from the inflammatory circulation: or,

It must be greater in those circulating only serum, than in those supplied with red blood; and the pain, which is the perception of change, will be proportioned to the extent of the change, or the greater the change, the greater the pain.

Having considered the faculty of sensation, as far as it appears to depend upon the nature of the impression and the condition of the part that receives it; the varieties that result from difference of texture in the organ will be reserved for future consideration.

Art. II. *On the Influence produced upon the Secretion of Milk in the Ass, by taking away the Foal. By Sir* E. Home, *Bart.; in a Letter to the Editor.*

Dear Sir,

As one of the objects of your Journal is to take notice of curious circumstances that are met with in natural history, I send you the following observations made by the late John Hunter, on the influence produced upon the secretion of milk in the ass, by taking away the foal.

He says, that it is universally known, that many animals that have brought forth young shall continue to give milk, not only after the young are removed, but even for years, when the impression of having had young must have been entirely forgotten. The cow, and goat, he gives as instances of this kind; but in the ass the secretion of milk is not continued after the mother has lost the impression of the existence of the foal: this is a fact so well known to the keepers of asses, that whenever an ass's foal dies, they take every means in their power to keep up the impression in the mother of the foal being still alive, to keep her in milk. For this purpose they take off the skin of the foal, and preserve it, so that it may be occasionally thrown over the back of another foal, and smelled by the mother, more particularly at the time they are milking her. The ass, under the deception of having her own foal, gives down her milk, and the secretion is carried on as usual, and she is kept in milk; but if this artifice is neglected she soon goes dry. This appeared to Mr. Hunter so curious a fact, that although it was well attested by every ass keeper to whom he spoke upon the subject, he could not give it full credit, till he had put it to the test of experiments. He took an ass in milk, that had a foal, and kept them apart every night, but had the mother milked in the morning in the presence of the foal; this was done for more than a month without there being any diminution in the morning's milk. The foal was then taken away altogether, and the

mother was milked, instead of being sucked by the foal, particularly in the evening, at the same hour at which the foal had been taken from her, and again in the morning at the usual hour. The milk taken in the morning was always compared with that taken the morning before, but in three mornings the quantity was lessened; and the fifth morning there was hardly any. The foal was then restored to her, but she would not allow it to suck. The experiment was repeated with similar results.

Your's truly,

EVERARD HOME.

ART. III. *Conjectures respecting the original Formation of the Arabic Digits,* 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. *Communicated by* JOHN DISNEY, *Esq.*

IN the various researches of literature, the forms even of letters have not been considered as unworthy of attention; and the investigation has, in some instances, tended to explain and facilitate their use in an eminent degree.

Of this we have several instances, particularly in regard to the roman letters used as numerals, in the valuable Cyclopædia now publishing by Dr. Rees, from which I shall take two or three examples, sufficient to elucidate what I mean.

D. a numeral for 500, because *half* of the gothic ꟿ. M. the initial of Mille, 1000.

L. a numeral for 50, because it is half E., the ancient C., which stood for 100, the initial of Centum.*

And so are explained other Roman numerals.

From having observed these, it occurred to me, that it might not be difficult to find out how the Arabic numerals, or digits (as they are called), came by their present shapes; 1, 2, 3, 4, 5, 6, 7, 8, 9, 0.

* See the two letters D. and L.

The convenience and utility of these signs in the operations of arithmetic and science need no comment: but one seems quite at a loss to know how calculations of any extent could be carried on by Roman numerals. Each figure was a sum, 4 was IV. i. e. 5—1, and so placed, that one can as easily suppose it to be six; for there is no reason why the right hand figure may not be added to the left hand, as well as the left hand subtracted from it: one instance more; to express 29, the sum is both addition and substraction, XXIX. i. e. $10 + 10 + \overline{10 - 1}$.

I only notice this, as shewing, that Arabic figures deserve at least as much attention as the Roman. In attempting to develope these several forms, I think I have succeeded in eight; the other two, 7 and 9, have hitherto defied all my efforts; perhaps some one else, to whom the subject may be amusing, may succeed better.

I must in the outset observe, that I found my whole conjecture upon two hypotheses; the first of which I have borrowed from the editors of the new Cyclopædia, viz. what they call the *roundness* of letters, arising from more rapid writing, as they instance in D, which, they say, " is no other than the " Greek Δ rounded a little by making it at two strokes."

This *rounding* I have availed myself of in the following figures, as will be seen: the second I have assumed myself, and is this; that while the Romans made every figure representing unity perpendicular, as, I. II. &c. the inventors of the Arabic figures varied from this, by making it both ways; perpendicular, as 1, and horizontal, as =, in *two*, and ≡, in *three*; and all higher compounds either way. I shall now proceed to take each figure, founded on these data, in its turn.

1, requires no more than has been already stated.

2, was formed =, which, written quickly, became Z : and, by the *rounding* attendant upon hurry in writing, becomes further changed into 2.

3, in like manner was formed of ≡, written quickly, and rounded into 3, which still makes three distinct points to the left hand.

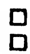
4, was, I suppose, a square □, i. e. = with two perpendi-

culars || added, one at each end, which, when written quickly, is most easily done by taking the two opposite angles at one stroke each, thus , as every one knows who has ever written geometrical problems; and these, by careless uniting, soon cross each other ; and this makes our present 4, at first actually a four-sided figure.

5, is as easily formed from 3; thus , which, with two (perpendicularly) added, is soon made into ; and that hurried, and consequently rounded, is now 5.

6. Six formed from five , by adding one to the lowest left-hand point, ; or it may be □ (four), with the two lines added angle-wise at the top r, and  easily rounds itself into 6.

7, has hitherto foiled me.

8, is very obviously two □s, thus  joined together make , and quickened into 8.

9, like 7, must be left to some more happy conjecturer.

0, needs very little explanation: for being a circle, has no defined sides sufficiently distinct to represent *any* number, and by its uniformity, was probably taken for none.

May 8, 1816.

Art. IV. *A systematic View of the Plants contained in the "Liliacées par* J. P. Redouté." *Tomes* 8; *fol. Paris,* 1802—1816. *By* John Bellenden Ker, *Esq.*

It is not our intention to criticise either the text or the figures of the above work; but to arrange in order of system, in one general view, the very interesting portion of monocotyledonous vegetables distributed miscellaneously throughout the eight costly volumes of which it consists. In doing this,

we shall attend, as far as the figures and descriptions will admit, to the emendation of the names and synonymy, by far the least commendable parts of that splendid undertaking; and shall occasionally add such notes as we may deem of use.

The word "Liliacées," the title of the book, is adopted in the comprehensive sense attributed to it by Tournefort, as the name of an order in his system; and is here intended practically to admit any ornamental or curious monocotyledonous plant. Each species is the subject of an engraving printed in colours, and is accompanied by two pages of its history in French.

In the subsequent enumeration, when the name of a species is altered to another, that for which it has been corrected follows in italic character, with the number of its place in the work annexed. When no alteration is intended, the name stands, as in the work, in Roman characters, with the number of its place annexed, and followed by a synonym, if the species happens to have been recorded elsewhere. The arrangement is according to the method of Linnæus, dropping, however, the class and order *Monadelphia Triandria*, as worse than useless. The genera follow as they stand in the Hortus Kewensis.

ABBREVIATIONS.

H. K. The second edition of the Hortus Kewensis.
B. M. Curtis's Botanical Magazine.
A. B. A Treatise on the Ensatæ by Mr. Bellenden Ker in the first volume of the Annals of Botany.
B. R. The Botanical Register.

MONANDRIA MONOGYNIA.

Canna indica. 201. H. K.

We follow the Hortus Kewensis in holding it to be that of Mr. Roscoe. Else we should have said it belonged to the *lutea* of Mr. R., described as having the interior limb trifid, which that of the present plant appears to be. At all events it can never be the same with the figure in Miller's Illustration, quoted as its synonym in H. K. That we should take to belong to the *patens* of Mr. R.

Canna glauca. 354. H. K.

Canna flaccida. 107. H. K.

Canna gigantea. 331.

A species not recorded in any other work. Now in our own gardens.

Maranta arundinacea. 57. H. K.

Thalia dealbata. H. K.
Perania stricta. 342.

Hedychium coronarium. 436. H. K.

Alpinia nutans. H. K.
Globba nutans. 60.

Alpinia calcarata. H. K.
Globba erecta. 174.

Kæmpferia rotunda. H. K.
Kæmpferia longa. 49.

Kæmpferia Galanga. 144. H. K.

Kæmpferia angustifolia. 389. H. K

Curcuma longa. 473. H. K.

TRIANDRIA MONOGYNIA.

Crocus minimus. 81.

An unrecorded species. The smallest flower of the genus yet known to us. It seems to be the connecting species of CROCUS with TRICHONEMA, with which it agrees in the narrowness of the stigmas, and by which it recedes from CROCUS Native of Corsica.

Crocus vernus. 266. H. K.

Crocus biflorus. 294. H. K.

Why this has been called with us the *Scotch Crocus* we have never been able to learn. Its native place was, we believe, unknown to botanists till we found specimens of it in the Herbarium of the Chevalier Pallas, which had been collected in Russian Tartary.

Crocus susianus. 293. H. K.

A species which had been confounded with the *vernus* of these parts of Europe. We found it in the above mentioned Herbarium, among the plants gathered in Russian Tartary by the Chevalier Pallas. it was also found by Mr. Marschall, of Bieberstein, and described in the Flora Taurico - Caucasica as a variety of his *Crocus reticulatus*. The remarkable reticulated covering of the bull-tuber, distinguishes it at once from all other species of the genus.

Crocus mæsiacus. H. K.

Crocus luteus. 196.

Native of the Levant. Varies by yellow and cream coloured corollas. The most universally dispersed in the gardens of Europe of any species of the genus.

Crocus sativus. 173. H. K.

Trichonema Bulbocodium. H. K.

Ixia Bulbocodium. A. 88.

Two species are confounded together in this place, the European and North African plant, which is here the variety A. and the one from South Africa which constitutes the variety B.

Trichonema roseum. B. M.

Ixia Bulbocodium. 88. B.

Trichonema roseum. v. *lutea*. B. M.

Ixia recurva. 1. *filifolia*. 2. 251. From the dried plant.

Geissorhiza secunda. H. K.

Ixia secunda. 406.

Hesperantha radiata. H. K.

Ixia radiata. 441.

Sparaxis grandiflora. H. K.

Ixia grandiflora, 139.

Sparaxis grandiflora. H. K.

Ixia grandiflora. 362.

Sparaxis grandiflora. β. H. K.

Ixia Liliago. 109.

Sparaxis bulbifera. H. K.

Ixia bulbifera. 128.

Sparaxis bulbifera. β.

Ixia anemoniflora. 85.

A very distinct species from the *I. anemoniflora* of Jacquin for which it has been mistaken. In that the tube is not longer than the spathe, which is remarkably short, and there is never more than one terminal flower, which is of another colour, with segments of a quite different form. The present plant may be what we have called SPARAXIS *lacera* in the enumeration of the species of SPARAXIS in No. 799 of Curtis's Botanical Magazine.

Sparaxis tricolor. H. K.

Ixia tricolor. 129.

Ixia capillaris. β. B. M.

Ixia rapunculoides. 431.

This variety has been left out in

the last edition of the Hortus Kewensis; where the varieties α and γ of the Botanical Magazine stand as separate species. Had the present variety, which connects the two others so as to leave no interval for specific difference, been inserted, it would have been impossible to have established the species *linearis* and *aulica*. The present shews them to be one species, at least in our view.

Ixia capillaris. γ. B. M.
Ixia aulica. H. K.
Ixia phlogiflora. 432.

Ixia patens. 140. H. K.
Ixia filiformis. 30.
Figured twice over.

Ixia patens. β. *Leucantha*.
Ixia leucantha. Jacquin.
Ixia candida. 426.

Ixia flexuosa. H. K.
Ixia polystachia. 126.

Ixia erecta. v; *lutea*. H. K.
Ixia dubia. 64.

Ixia conica. 138. H. K.

Ixia conica. β. *citrina*. H. K.
Ixia fusco-citrina. 86.

Ixia maculata. 137. H. K.

Ixia maculata. H. K.
Ixia viridiflora. 476.

Ixia monadelpha. H. K.
Galaxia Ixiæflora. 41.

Surely it is little less than perverseness to retain the class and order *Monadelphia Triandria* in the Linnean arrangement, when both may be resolved into *Triandria Monogynia* with such advantage to natural affinity; which it interrupts without the compensation of any one useful point to the system in which it is yet left to stand.

Ixia scillaris. 127. H. K.

Ixia crispa. 433. H. K.

Anomatheca juncea. H. K.
Gladiolus junceus. 141.

The *Lapeyrousia juncea* of Pourret in the Tholouse Transactions, is adduced by M. Redouté as a synonym to this species; but that is the *Gladiolus anceps* of Thunberg, and quite a distinct species, since arranged under *Lapeyrousia*, by the title of *anceps*, in the treatise on the *Ensatæ* in the first volume of the Annals of Botany.

Anomatheca xanthospila.
Gladiolus xanthospilus. 124.

As far as we can decide from the figure and description, an unrecorded species; and agreeing in more points with this genus than with *Gladiolus* or any other of the order. But for our opinion we rely solely on the accuracy of the figure; never having met with a specimen of the plant.

Tritonia miniata. H. K.
Ixia crocata. 335.

This is not the *Ixia crocata* of Linnæus and others, which does not appear in the work, although the oldest as well as (commonest species) in the gardens of Europe.

Tritonia deusta. H. K.
Ixia miniata. B. 89.

Tritonia squalida. H. K.
Ixia hyalina. 87.

And the true *Ixia lancea* of Thunberg; a fact which had escaped the acute synonymists who have compiled the two editions of the Hortus Kewensis. The *Ixia lancea* of Jacquin is the *aulica* of the Hortus Kewensis; our *capillaris* γ, and the *phlogiflora* of the present work. *See above*.

Tritonia lineata. H. K.
Gladiolus lineatus. 55. et 400 bis.

Tritonia securigera. H. K.
Monbretia securigera. 53.

Tritonia refracta. B. R.
Gladiolus refractus. 419.

Tritonia longiflora. H. K.
Ixia longiflora. 34.

Watsonia plantaginea. H. K.
Ixia plantaginea. 198.

Watsonia spicata. H. K.
Ixia cepacea. 96.

Watsonia humilis. H. K.
Gladiolus laccatus. 343.

Watsonia humilis. H. K.
Gladiolus strictiflorus. 399.

Here mistaken for the *Watsonia strictiflora,* No. 1406 of Curtis's Botanical Magazine, a very distinct species.

Watsonia Meriana. H. K.
Gladiolus Merianus. 11.

Gladiolus Cunonia. H. K.
Antholyza Cunonia. 12.

Gladiolus Watsonius. 369. H. K.

Gladiolus hirsutus. 273. H. K.

Gladiolus hirsutus. *var. alia.*
Gladiolus orobanche. 125.

Four varieties of this species have been published in Curtis's Botanical Magazine. And the present seems a new one. In the last edition of the Hortus Kewensis the species has been divided into *brevilius* and *hirsutus,* but in our opinion causelessly.

Gladiolus tristis. 35. H. K.

Gladiolus gracilis. 425. H. K.

Gladiolus recurvus. H. K.
Gladiolus ringens. 123.

Gladiolus carneus. H. K.
Gladiolus cuspidatus. 36.

Gladiolus cuspidatus. 136. H. K.
This is the real *Gladiolus undulatus* of Linnæus.

Gladiolus blandus. H. K.
Gladiolus carneus. 65.

Gladiolus blandus. H. K.
Gladiolus carneus. 377.

Gladiolus angustus. 344. H. K.

Gladiolus undulatus. 122. H. K.
This is not the *undulatus* of Linnæus, which is the *cuspidatus* already enumerated But the new names are too generally established to be now changed with advantage for the old.

Gladiolus communis. 267. H. K.

Gladiolus cardinalis. 112. H. K.

Melasphærula graminea. H. K.
Diasia iridifolia. 54.

Melasphærula graminea. H. K.
Diasia graminifolia. 163.

Antholyza æthiopica. 110. H. K.

Antholyza æthiopica. H. K.
Antholyza prœalta. 387.

Babiana stricta. γ. B. M.
Gladiolus mucronatus. 142.

Babiana stricta. β. B. M.
Gladiolus strictus. 90.

Babiana tubiflora. α. H. K.
Gladiolus inclinatus. 44.

Babiana tubiflora. β. H. K.
Gladiolus tubatus. 264.

Babiana tubiflora. H. K.
Gladiolus tubiflorus. 361.

Wachendorfia thyrsiflora. 93. H. K.

Aristea cyanea. 462. H. K.

Witsenia maura. 245. H. K.
From a dried plant.

Witsenia maura. 473. H. K.
From the living plant.

Witsenia corymbosa. 453. H. K.

Galaxia ovata. 246. H. K.
From the dried plant.

Moræa collina. H. K.
Sisyrinchium collinum. 250.
From the dried plant. This is the true *Moræa juncea* of Linnæus.

Moræa collina. H. K.
Sisyrinchium elegans. 171.

But not Jacquin's *Moræa elegans*, as supposed by M. Redouté.

Moræa edulis. H. K.
Iris Sisyrinchium. 458.

A Cape species, here mistaken for one that belongs to the southern parts of Europe, and which had been already represented in the work.

Moræa tristis, H. K.
Morea sordescens. 71.

Moræa Sisyrinchium. H. K.
Iris Sisyrinchium. 29.

Moræa tricuspis. H. K.
Vieusseuxia glaucopis. 42.

Ferraria undulata. 28. H. K.

Iris Pseud-Acorus. 235. H. K.

Iris spuria. α. H. K.
Iris spuria. 349.

Iris spuria. δ. B. M.
Iris ochroleuca. 354.
Iris halophila. H. K.

Iris spuria. γ. B. M.
Iris Monnieri 236.
Iris ochroleuca. H. K.

Iris spuria. ζ B M.
Iris stenogyna. 310,

We have scarcely a doubt but that the above four plants, as well as the two other varieties represented in Curtis's Botanical Magazine, belong to this species. The one that differs most materially is the variety ε. represented in the 1514th plate of the Botanical Magazine.

Iris fœtidissima. 351. H. K.

Iris moræoides. B. M. 1407, *in obs.*
Moræa iridioides. 45. H. K.

Iris graminea. 299. H. K.

Iris sibirica. H. K.
Iris pratensis. 237.

Iris sibirica. *β. alba*. 438. H. K.

Iris sibirica. *pumila*. 420. H. K.

Iris versicolor. 339. H. K.

Iris susiana. 18. H. K.

Iris cristata. 376. H. K.

Iris pumila. *cærulea*. 262. H. K.

Iris pumila. *violacea*. 261. H. K. et B. M. 1261.

Iris pumila. *lutescens*. H. K.
Iris lutescens. 263.

Iris lutescens. H. K.
Iris virescens. 295.

Iris variegata. 292. H. K.

Iris lurida. 318. H. K

Iris sambucina. α. 365. H. K.

Iris sambucina. *β. squalens*. 338. H. K.

Iris florentina. 23. H. K.

Iris flavescens. 375.

This seems to us to be merely a faded variety of *sambucina*.

Iris pallida. 366. H. K.
The real *sambucina of* Linnæus.

Iris aphylla. γ. B. M.
Iris plicata. 356. also of Lamarck.

Iris aphylla. β. B. M.
Iris Swertii. 306. also of Lamarck.

Iris aphylla α. B. M.
Iris amœna. 336.

Quite a distinct species from the *Iris amœna* of Waldstein's and Kitaibel's Flora Hungarica, for which it is mistaken. And is the *Iris nudicaulis* of Lamarck; and the variety α. of the *Iris aphylla* of B. M. 870.

Iris arenaria. 296.

An Hungarian plant first recorded in the Flora Hungarica of Waldstein and Kitaibel.

Iris curtopetala. 340.

Vieusseuxia iridioides; on the plate.

Taken from some abortive specimen, and not to be made out from either figure or description. Proba-

bly one of the varieties of *spuria*, or of a species near to it.

Iris fimbriata. 152. H. K.

Iris tuberosa. 48. H. K.

Iris xiphioides. 212. H. K.

Iris Xiphium. 337. H. K.

Iris alata. *Lamarck. encyc.*
Iris scorpioides. 211.

This species is figured in several of the works of the older botanists, but was first recorded as the *Iris alata* by the Chevalier Lamarck in his Botanical Encyclopædia. It is the *microptera* of Vahl. The figure given by M. Desfontaines in the Flora Atlantica is very defective and uncharacteristic.

Iris persica. 189. H. K.

Marica striata. B. M.
Sisyrinchium striatum. 66. *and* of H. K.

Marica plicata. B. M.
Sisyrinchium palmifolium. 352.
Sisyrinchium latifolium. H. K.

Marica convoluta. *nobis.*
Sisyrinchium convolutum. 47.

Marica tenuifolia. *nobis.*
Sisyrinchium tenuifolium. 275.

This and the foregoing were brought by Messrs. Humboldt and Bonpland from Mexico, and have been figured in Willdenow's Hortus Berolinensis. Neither is of the same species with the *Marica californica* of Curtis's Botanical Magazine, as supposed by M. Redouté.

Marica anceps. *nobis.*
Sisyrinchium gramineum. 282.
Sisyrinchium anceps. H. K.

Marica Bermudiana. *nobis.*
Sisyrinchium Bermudiana. 149.

Marica martinicensis. H. K.
Iris martinicensis. 172.

Marica Northiana. H. K.
Moræa vaginata. 56.

Tigridia pavonia. H. K.

Pardanthus chinensis. H. K.
Belamcanda chinensis. 121.

Heritiera tinctorum. 247.

This is the *Dilatris Heritieri* of Persoon's Synopsis Plantarum; the *Dilatris tinctoria* of Pursh; the *Heritiera Gmelini* of Michaux; and *Dilatris caroliniana* of Lamarck.

Commelina communis. H. K.
Commelina vulgaris. 206.

Commelina tuberosa. 108. H. K.

Commelina dianthifolia. 390.

We suspect this to be the *Commelina lanceolata* of Mr. Brown's Prodromus of the Flora of New Holland. But it is in vain to attempt to determine the species of this difficult genus from such figures as in this work; without being previously acquainted with the plant for which they are meant. It may be also the *C. angustifolia* of Vahl.

Commelina (*uncertain*).
Commelina africana. 207.

This is certainly not the plant it is given for, but a very distinct species. Whether described or not, we are unable to decide from this figure without knowing the plant.

Commelina dubia. 359.
Said to be nearly allied to *tuberosa.*

Commelina pallida. *Willdenow's Hortus Berolinensis.*
Commelina rubens. 367.

Commelina persicariæfolia. 472.

We do not pretend to have made out the species of *Commelina* in this work. It would be a fruitless attempt without having examined the plants themselves.

PENTANDRIA MONOGYNIA.

Heliconia Psittacorum. 151. H. K.

Heliconia Bihai. H. K.
Heliconia humilis. 382, 383.

Strelitzia Reginæ. 77, 78. H. K.

HEXANDRIA MONOGYNIA.

Bromelia Ananas. 455, 456. H. K.

Bromelia Pinguin. 396. H. K.

Bromelia Karatas. 457. H. K.

Pitcairnia bromeliæfolia. 75. H. K.

Pitcairnia angustifolia. 76. H. K.
We doubt whether this is really the species. See what has been observed in B. M. 1547.

Pitcairnia bracteata. α. H. K.
Pitcairnia latifolia. 73, 74.

Tradescantia virginica. 95. H. K.
The plate has been inscribed *Commelina erecta* by mistake.

Tradescantia rosea. 94. H. K.

Tradescantia erecta. 239. H. K.

Tradescantia Zanonia. H. K.
Commelina Zanonia. 192.

Tradescantia discolor. 168. H. K.

Pontederia cordata. 72. H. K.

Hæmanthus coccineus. 39. H. K.

Hæmanthus puniceus. 320. H. K.

Hæmanthus multiflorus. 204. H. K.

Hæmanthus pubescens. β. B. M. 1523 *in note.*
Hæmanthus albiflos. 398. *et* H. K.
Hæmanthus pubescens. H. K.
It has been enumerated both in the Hortus Kewensis and in the Botanical Magazine as a separate species, by the name of *H. albiflos*; but is since found to be a mere variety of *pubescens*.

Massonia scabra. H. K.
Massonia pustulata. 183.

Massonia angustifolia. 392. H. K.

Massonia ensifolia. H. K.
Massonia violacea. 386.

Galanthus nivalis. 200. H. K.

Leucojum æstivum. 135. H. K.

Leucojum autumnale. (150 *quoad fig.* 1.) H. K.

Leucojum tricophyllum. *Brotero in Flora lusitanica.*
Leucojum autumnale. (150 *quoad fig.* 2.)

Leucojum tricophyllum. *major.*
Leucojum grandiflorum. 217.

Narcissus biflorus. 405. H. K.

Narcissus poeticus. α. 160. H. K.

Narcissus pumilus. 409.
Seems to come very near to *Narcissus tenuior*, H. K. but is entirely white.

Narcissus incomparabilis. H. K.
Narcissus Gouani. 220.

Narcissus pseudo-Narcissus. 158. H. K.

Narcissus moschatus. δ. B. M.
Narcissus candidissimus. 188.
A small white variety of the *N. moschatus* of the Hortus Kewensis; figured in B. M. 1360.

Narcissus triandrus. B. M. 1262 et H. K.
Narcissus calathinus. 177.

Narcissus triandrus. γ. *alba.* B. M. et H. K.
Narcissus calathinus. 410.

Narcissus Tazzetta. 17.
The variety α. of the Hortus Kewensis.

Narcissus intermedius. 427.
The number refers to two figures of very distinct species; one of which is intended for the Narcissus, recorded under the same name in the Flora Gallica of M. L'Oiseleur des Longschamps; the other seems

the plant we have published in B. M. 1026, by the name of Narcissus orientalis. δ. *luteus.* The first seems to be a stranger to our collections, but approaches to *Narcissus bifrons.* B. M.

Narcissus dubius. 429 *Willdenow, in Species Plantarum.*

Narcissus bifrons. B. M. 1299.
Narcissus radiatus. 459.

This is rather said by guess than with any certainty; it seems intended for the plant we suppose it to be.

Narcissus Jonquilla. 159. H. K.

Narcissus calathinus. α. B. M. 934.
Narcissus lætus. 428.

Narcissus calathinus. β. *nobis.*
Narcissus odorus. 157.
Narcissus odorus. B. M. 78.

In the Hortus Kewensis the synonymy of this species, which is there divided into two by the names of *lætus* and *odorus*, has been in part misapplied. We have little doubt but that it is the plant intended by Linnæus for *N. calathinus.* Certainly it is that of his synonymy; and as there is no specimen in his Herbarium, that is now the best test of the species. The specific phrase, and what description is given, agree as nearly as those of Linnæus generally do, with the plant.

Narcissus Bulbocodium. 24. H. K.

Pancratium rotatum. H. K.
Pancratium disciforme. 155.

Pancratium maritimum. 8. H K.

Pancratium littorale. 154. β. B. M. 825.

Pancratium caribæum. B. M.
Pancratium speciosum. 156.
Pancratium fragrans. H. K.

Pancratium amœnum. H. K. et B. M. 1467. (*excluso Andrews's Reposit.*)
Pancratium fragrans. 413.

Pancratium speciosum. 412. H. K.

The synonymy from Redouté and the Botanical Magazine, quoted in the Hortus Kewensis, do not belong to this plant, but to *caribæum.*

Pancratium patens. *Redouté at the end of article* 414.
Pancratium declinatum. 358.
Pancratium declinatum. 414.

We take both the above figures to be of one and the same species, and different from the *declinatum* of Jacquin, which belongs to *caribæum.* Although long known in our gardens, has not been yet distinguished in any general enumeration of plants. We saw it this summer in blossom at Mr. Griffin's collection, South Lambeth.

Pancratium calathinum. B. M.
Pancratium calathiforme. 353.
Pancratium narcissiflorum of Jacquin's Fragmenta.

Pancratium illyricum. 153. H. K.

Pancratium parviflorum. 471.

Very near to the foregoing; but still, we believe, a distinct species. It seems to be one that connects its genus with Ornithogalum, through *nutans,* an anamalous species of that genus.

Pancratium amboinense. 384. H.K.

Pancratium coccineum: *of the Flora Peruviana of Ruiz and Pavon. tab.* 285. *fig.* 6.
Pancratium croceum. 187.

A species by which the genus connects with Amaryllis, through *tubispatha,* and other species near to that.

Crinum asiaticum. 348. H. K.

Crinum americanum. H. K.
Crinum Commelini. 322.

Crinum erubescens. 27. H. K.

Crinum pedunculatum. B. R.
Crinum taitense. 408.

Crinum pedunculatum. H. K.
Crinum americanum. 332

Agapanthus umbellatus. 6. H. K.

Agapanthus umbellatus. *minor.* 403. minor.

This is the older of the two in our collections: was that of Miller.

Anigozanthus flavida. 176. H. K.

Cyrtanthus obliquus. 381. H. K.

Cyrtanthus angustifolius. 388. H.K.

Amaryllis lutea. 148. H. K.

Amaryllis Atamasco. *minor.* 454. H. K.

Amaryllis Atamasco. 31. H. K.

Amaryllis formosissima 5 H. K.

Amaryllis Reginæ. 9. H. K.

Amaryllis equestris. 32. H. K.

Amaryllis reticulata. 424. H. K.

Amaryllis Belladonna. 180. H. K.

Amaryllis vittata. 10. H.K.

Amaryllis (*planta hybrida.*)
Amaryllis brasiliensis. 469.

The plant, which is offered here as a distinct species, is no other than a mule or cross-production between *vittata* and *Reginæ*. It was produced in our gardens some few years back from seed, procured by the union of two species brought together with that view. It forms a very handsome plant, uniting the principal beauties of both parents; and flowers constantly in the Spring, when it is seen in most of our principal nurseries, and it goes by the name of *Amaryllis Johnsoniana.*

Amaryllis ornata. *α.* H. K.
Amaryllis Broussonetii. 62.

Amaryllis gigantea. H. K..
Crinum giganteum. 181.

Amaryllis longifolia. 347. H. K.

Really the species intended by Jacquin, L'Heritier, Wildenow, and the editors of the Hortus Kewensis, who had mistaken it for the Linnæan plant, which is, however, the *Brunsvigia falcata* of No. 1443 of the Botanical Magazine, and the *Amaryllis falcata* of others. See our account of that in the place we have cited from Curtis's Botanical Magazine, where the mistake is detected which had existed for so long a period, and been sanctioned by so many writers.

Amaryllis aurea. 61. H. K

Amaryllis sarniensis. 33. H. K.

Amaryllis curvifolia. 274. H. K.

Amaryllis humilis. 449. H. K.

Amaryllis undulata. 115. H. K.

Amaryllis (*incerta.*)
Cyrtanthus vittatus. 182.

The figure of this plant has been copied from an old drawing on vellum in the library of the French Museum of Natural History. It is not known whether of the natural size or diminished; nor whether it is a bulbous rooted plant or not. Seems to us to be an *Amaryllis.* But no certain judgment can be formed from such a figure, unless the plant had been previously inspected; and it does not seem to be intended for any one which is at present in our collections.

Brunsvigia multiflora. H. K.
Amaryllis Josephinæ, 370, 371, 373.

Sowerbæa juncea. 341. H. K.

Allium gracile. H. K.
Allium fragrans. 68.
Allium inodorum. H. K.

Of the few iterations of the same

plant by different names in the late edition of the H. K.; the present species is one. It is there recorded under the names of *inodorum* and *gracile*, the one as a hardy, the other as a hot-house plant: while the figures quoted separately to each were certainly taken from plants known to us to be of the same stock. It had been treated as a hot-house plant by mistake: being in fact entirely hardy, and propagating rapidly in almost any situation. The seeds are found generally to contain more than one embryo. Said by Mr. Pursh to be a native of Carolina. It had been accidentally introduced into the Isle of France, where it has become a troublesome weed, over-running large tracts of land. The fragrance is only given out after sunset.

Allium striatum. 50. H. K.

Certainly the *Ornithogalum bivalve* of Linnæus; and a native of Carolina, not of the Cape of Good Hope, as generally asserted.

Allium cernuum. 345. B. M.

A native of America.

Allium bisulcum. 286. B. M.

Allium angulosum. 281. H. K.

Allium obliquum. 363. H. K.

Allium nutans. 233. H. K.

A variety with longer narrower leaves than that figured in B. M.

Allium magicum. B. M.

Allium nigrum. 102. H. K.

The true *A. magicum* of Linnæus: whose original *nigrum* was the *narcissiflorum*, if not *roseum*; which he afterwards, through forgetfulness, transferred into the present plant, without dropping his *magicum*, of which he had lost sight, and has thus left to stand by two names in his later works.

Allium triquetrum. 319. H. K.

If really meant for the plant, a very bad likeness. It resembles more a figure of *Allium striatum.*

Allium ursinum. 303. H. K.

Allium Chamæ-Moly. 325. H. K.

Allium oleraceum. H. K.

Allium carinatum. 368.

Allium oleraceum; *capsuliferum vel cum umbellâ sine bulbis.*

Allium paniculatum. 252.

A mere variety of *oleraceum* without bulbs; falsely quoted in H. K. to *paniculatum*.

Allium paniculatum. H. K. *and* B. M.

Allium pallens. 272.

Allium pallens. B. M. *and* H. K.

Allium longispathum. 316.

The true *pallens*, which after all is but a capsuliferous variety of *Allium carinatum*. See the remarks offered by us on this plant in Curtis's Botanical Magazine. 1420.

Allium flavum. 119. H. K.

Allium caucaseum. B. M. (1143 *in a note on the other side the leaf.*)

Allium globosum. 179.

Allium paniculatum. B. M. 973.

Allium saxatile. Flora taurico-caucasica of Maschall von Bieberstein.

Allium arenarium. 379. H. K.

Allium Ampeloprasum. 385. H. K.

The *A. Ampeloprasum* of the Flora Hungarica, quoted to this species in H. K. seems to us to belong to *A. arenarium*

Allium spherocephalum. 391. H. K.

Allium tataricum. 98. H. K.

This is the *Allium ramosum* of the elder Linnæus; but not being recognised by the son, has been recorded by him as a separate species. It stands under both names in all later enumerations of plants, except the Hortus Kewensis.

Allium moschatum. 100. *Willdenow's Species Plantarum.*

We have no doubt but that the *capillaceum* of Cavanilles, and the *setaceum* of the Flora Hungarica by Waldstein and Kitaibel are of this species.

Allium illyricum. *Willdenow's Spec. Plant.*
Allium brachystemon. 374.

A weak specimen.

Allium roseum. 213. H. K.

Allium subhirsutum. 305. H. K.

Allium subhirsutum. H. K.
Allium ciliare. 311.

Allium Victorialis. 265. H. K.

Allium Moly. 97. H. K.

Allium mutabile. 240. *Michaux's Flora boreali-americana.*

This figure is taken from a dried specimen: we believe Michaux's specimen of the species.

Allium scorzoneræfolium. 97.

Has the appearance of a yellow variety of *roseum*; but seems to have been taken from an imperfect specimen.

Allium carolinianum. 101.

Not to be determined by this figure.

Allium album. 300.

Native of the South of Europe.

Allium lusitanicum. 271.

The figures of this and the following *Alliums* have not enabled us to decide whether they are such as have been recorded elsewhere. We have not recognised any plants resembling them in any of the collections in this country. This seems to come near to *Allium suaveolens*; but the stamens are much shorter.

Allium denudatum. 357. *uncertain.*

Allium foliosum. 214.

Seems scarcely distinct from *A. Schœnoprasum.*

Allium obtusiflorum. 118. *uncertain.*

Lilium candidum. 199. H. K.

Lilium bulbiferum. 210. H. K. *var. α.*

Lilium chalcedonicum. H. K.
Lilium pomponium. 7.

Lilium chalcedonicum. 276. H. K.

Lilium pumilum. 378. B. R.

A beautiful slender-leaved species from Moscow, not Peru, as here supposed.

Lilium tigrinum. 395. H. K.

Lilium canadense. 301. H. K. *var. α.*

Lilium canadense. H. K. *β.*
Lilium penduliflorum. 105.

Lilium superbum. 103. H. K.

Lilium pomponium. H. K. *β.*
Lilium pyrenaicum. 145.

Lilium Martagon. 146. H. K.

Lilium philadelphicum. 104. H. K.

Fritillaria imperialis. 131. *α.* H. K.

Fritillaria persica. 67. H. K.

Fritillaria Meleagris. 292. H. K.

Fritillaria latifolia. 51. H. K.

Eucomis undulata. H. K.
Eucomis regia. 175.

Eucomis punctata. 208. H. K.

Uvularia amplexifolia. H. K.
Streptopus amplexifolius. 259.

Uvularia grandiflora. H. K.
Uvularia perfoliata. 184.

Gloriosa superba. H. K.
Methonica superba. 26.

Erythronium Dens Canis. 194. H. K.

Tulipa cornuta. 445. B. R.

A very singular and beautiful species from Persia.

Tulipa suaveolens. 111. H. K.

Tulipa sylvestris. 165. H. K.

Tulipa celsiana. 38. B. M. 1135; *in the note on the other side the leaf.*
Tulipa breyniana. B M. 717.
T. sylvestris. β. Marschall von Bieberstein in Flora Taurico-caucasica.

We found specimens of this species in the Herbarium of the Chevalier Pallas, which had been collected on the banks of the Wolga. It belongs to Russian Tartary, where it is found in company with *Tulipa biflora. Tulipa gesneriana* grows wild on the desarts on the borders of the Caspian Sea, and was gathered there by Pallas.

Tulipa elusiana. 37. B. M.

Grows near Florence; in Sicily also; and in the vicinity of Madrid.

Tulipa Oculus Solis. 219.

Very near to *T. gesneriana.* Not distinctly recorded in any other place. Native of the South of France.

Albuca major 69. H. K.

Albuca minor. 21. H. K.

Albuca fastigiata. 474. H. K.

Albuca abyssinica. 195. *Willdenow's Species Plantarum.*

Albuca cornuta. 70.

We believe this not to be different from *Albuca altissima.* H. K.

Hypoxis stellata. 169. H. K.

Hypoxis sobolifera. 170. H. K,

Hypoxis erecta. 355. H.K.

Hypoxis luzulæfolia. 260.

Figured from a dried specimen collected at the Cape of Good Hope, and may be almost any thing.

Gagea lutea. B. M. 1200.
Ornithogalum luteum. 302. H. K.

Gagea is naturally more nearly related to *Hypoxis* than *Ornithogalum.*

Gagea minima. *nobis.*
Ornithogalum spathaceum. 242.
Ornithogalum minimum. H. K

Gagea fistulosa. *nobis.*
Ornithogalum fistulosum. 221.
Ornithogalum bohemicum. Willdenow's Spec. Plant.

Possibly the three are mere varieties.

Gagea serotina. *nobis*
Phalangium serotinum. 270.
Anthericum serotinum. H.K.

Peliosanthes Teta. 415. H. K.

Eriospermum lanceæfolium. 394. H. K.

Ornithogalum pyrenaicum. 234. H. K.

Ornithogalum thyrsoides. H. K.
Ornithogalum arabicum. 63.

In the Hortus Kewensis this figure has been quoted for the synonym of *O. arabicum,* to which it certainly does not belong.

Ornithogalum thyrsoides. 333. H.K.

Ornithogalum lacteum. 418 H.K.

Ornithogalum longibracteatum. 120.
Willdenow's Spec. Plant.

Ornithogalum aureum 439. H. K.
β. flavissimum.

Ornithogalum pyramidale. 422. H.K.

Ornithogalum juncifolium. H. K.
Ornithogalum tenuifolium. 312.
Ornithogalum Radolphi. Jacquin's Eclog Plant.

Ornithogalum maritimum. *Tournefort.*
Scilla maritima. 116. H. K.

We take this to be the connecting species of its genus with *Drimia,* by the *altissima* of that. (See B. M. 1074.)

Ornithogalum nutans. 253. H. K.

Connects its genus with *Pancratium.*

Ornithogalum trigynum. 417. *uncertain.*

Comes near to *pyrenaicum* and *stachyoides*; but is represented with three minute styles, an anomaly in this genus, if correctly shewn.

Ornithogalum umbellatum. 143 H. K.

Scilla Lilio-hyacinthus. 205. H. K.

Scilla italica. 304. H. K.

Scilla peruviana. 167. H. K.

Scilla amœna. 298. H. K.

Scilla amœna. *β. sibirica.* 130. B. M.
Scilla sibirica. H. K.

This has been quoted in H. K. t the plant from the Levant.

Scilla campanulata. *major.* 435. H. K.

Scilla campanulata. *minor.* H. K.
Scilla patula. 225.

Scilla bifolia. 254. H. K.

Scilla verna. H. K.
Scilla umbellata. 166.

Cited in H. K. as a synonym of *italica.*

Scilla autumnalis. 317. H. K.

Scilla obtusifolia. 190.

Scilla lingulata. 321. *Persoon's Synopsis Plantarum.*

This and the preceding we have never met with in the collections of this country. Native of Barbary.

Scilla serotina. B. M. 859. 1185.
Hyacinthus serotinus. 202. H. K.

An ambiguous species, approaching in some material points to the genus Albuca.

Scilla non scripta. 224
Hyacinthus non scriptus. H. K.

Scilla romana. B. M.
Hyacinthus romanus. 334. H. K.

Bellevalia operculata. Lapeyrouse in Schrader's neues Journal fur die Botanik

Hyacinthus amethystinus. 14. H. K.

Hyacinthus orientalis. 465. H. K.

Muscari comosum. 231.
Hyacinthus comosus. H. K.

Muscari racemosum. 232.
Hyacinthus racemosus. H. K.

Muscari moschatum. B. M.
Muscari ambrosiacum. 132.
Hyacinthus Muscari H. K.

Muscari botryoides. 364.
Hyacinthus botryoides. H. K.

Cyanella capensis. 373. H. K.

Asphodelus luteus. 223. H. K.

Asphodelus capillaris. 380.

Looks like a narrow-leaved variety of the foregoing *luteus.*

Asphodelus tauricus. 470. *Marschall flor. taur. cauc.*

Asphodelus ramosus. 314. H. K.

Asphodelus fistulosus. 178. H. K.

Phalangium ramosum. 287.
Anthericum ramosum. H. K.

Phalangium Liliago 269. B. M.
Anthericum Liliago. H. K.

Anthericum pomeridianum. *nobis.*
Scilla pomeridiana. 421. *Pers. Syn.*

Not having had an opportunity of seeing any perfect specimen, we have placed the species in this genus. That it cannot be a Scilla is evident. It may be of a distinct genus, and, perhaps, belong to Phalangium. We take it to be the same with a specimen in the Bankian Herbarium from the Cape of Good Hope, under the title of *Anthericum scabrum.* The sort of bulb hat belongs to it is very different from the tunicated one with membranous integuments, which is that of *Scilla.* This approaches nearer to he bulbicipitous fibrous radication.

Anthericum planifolium. *Willdenow Spec. Plant.*
Phalangium bicolor. 215.

* We have never seen the living plant; which may probably require to be removed from *Anthericum*, but certainly cannot be included in *Phalangium*.

Anthericum longiscapum. 423. B.M.

Anthericum frutescens. 284. H. K.

Anthericum alooides. 283. H. K.

Anthericum annuum. 397. H. K.

Chlorophytum elatum. *Brown.*
Phalangium elatum. 191.
Anthericum elatum. H. K.

We have placed this plant in the above genus on the suggestion of Mr. Brown in his Prodromus of the Flora of New Holland. We have not seen the plant alive, but suspect that it is at too great a distance from the species *(inornatum)*, from which we established the genus CHLOROPHYTUM in No. 1071 of Curtis's Botanical Magazine, to be included as a congener with that.

Arthropodium paniculatum. H. K.
Anthericum milleflorum. 58.

Arthropodium paniculatum. H. K.
Phalangium pendulum. 360.

We take this to be the same with the preceding, published over again by mistake.

Narthecium ossifragum. *Smith and Sowerby's English Botany.*
Abama ossifraga. 218.
Anthericum ossifragum. H. K.

Echeandia terniflora. 313.
Anthericum reflexum. Willdenow's Spec. Plant.
Conanthera Echeandia. Persoon's Synopsis Plant.

Asparagus horridus. 388.

Asparagus tenuifolius. 434.
Asparagus officinalis. β Willdenow's Spec. Plant.

Asparagus amarus. 446.
Asparagus officinalis. β. Willdenow's Spec. Plant.

Asparagus tricarinatus. 451. *uncertain.*

Asparagus sarmentosus. 460. H. K.

Asparagus pectinatus. 409. *uncertain.*

Dianella ensifolia. 1. H. K.

Dianella cærulea. 79. H. K.

Dracæna ferrea. H. K.
Dracæna terminalis. 91.

Dracæna cernua. *Willdenow's Spec. Plant.*
Dracæna reflexa. 92.

Dracæna fragrans. H. K.
Aletris fragrans. 117.

Sanseviera guineensis. 330. H. K.

Sanseviera zeylanica. 290. H. K.

Sanseviera carnea. 323. H. K.

Convallaria majalis. 227. H. K.

Convallaria Polygonatum. H. K.
Polygonatum vulgare. 258.

Convallaria verticillata. H. K.
Polygonatum verticillatum. 244.

Convallaria multiflora. H. K.
Polygonatum multiflorum. 229.

Convallaria sibirica. *nobis.*
Polygonatum sibiricum. 315. uncertain.

Convallaria latifolia. *Willdenow's Spec. Plant.*
Polygonatum latifolium. 243.

Smilacina racemosa. 230.
Convallaria racemosa. H. K.

Smilacina stellata. 185.
Convallaria stellata. H. K.

Smilacina bifolia. *nobis.*
Maianthemum bifolium 216. fig. 2.
Convallaria bifolia. H. K.

Smilacina canadensis. *Pursh's Flora of North America.*
Maianthemum canadense. 216. fig. 1.

Ophiopogon japonicus. H. K.
Convallaria japonica. 80.

Polianthes tuberosa. 147. H. K.

Drimia lanceæfolia. B. M. 1380.
Lachenalia lanceæfolia. 59. H. K. B. M. 643.
Hyacinthus revolutus. H. K. nec Linn. Suppl..

Appears, by mistake, under two names in the Hortus Kewensis; of which it is the *Hyacinthus revolutus* and *Lachenalia lanceæfolia.* The *Hyacinthus revolutus* of the Supplementum of the younger Linnæus, is the *Drimia undulata* of Jacquin.

Drimia elata. 430. H. K.

Phormium tenax. 448, 449. H. K.

Lachenalia angustifolia. 162. H. K.

Lachenalia tricolor. 2. H. K.

Lachenalia tricolor. β. H. K.
Lachenalia luteola. 297.

Lachenalia pendula. 52. H. K.

Lachenalia pallida. 22. H. K.
L. mediana of Jacquin.

Lachenalia viridis. H. K.
Hyacinthus viridis. 203.

We find it made a genus, by the title of *Zuccagnia*, in Schrader's New Botanical Journal.

Veltheimia glauca. 440. H. K.

Veltheimia viridifolia. H. K.
Veltheimia capensis. 193.

Tritoma pumila. H. K.
Veltheimia abyssinica. 186.

This has been copied from some of the old drawings on vellum in the library belonging to the National Botanic Garden at Paris.

Tritoma media. 161. H. K.

Tritoma Uvaria. 291. H. K.

Yucca gloriosa. 326, 327. H. K.

Yucca aloifolia. 401, 402. H. K.

Yucca filamentosa. 277, 278. H. K

Agave virginica. H. K.
Agave yuccæfolia. 328, 329.

We take this to be an [illegible]gerated representation of the sp[illegible] we have placed it under; or, perhaps, one of a finer specimen of the species than is usually produced in the collections of this country.

Alstrœmeria montana. *nobis.*
Amaryllis montana. 241. Willdenow's Spec. Plant.

We believe this plant, although common in Syria, and other regions of the Levant, has never reached any European collections. The present drawing is from a dried specimen. The species can never be brought within the genus *Amaryllis*; but as far as we can judge from a Liliaceous plant, when dried, seems to rank naturally with the species in *Alstrœmeria.*

Alstrœmeria Ligtu. 40. H. K.

Alstrœmeria Pelegrina. 46. H. K.

Hemerocallis cærulea. 106. H. K.

Hemerocallis japonica. 3. H. K.

Hemerocallis Liliastrum. B. M. 1433, *in note.*
Phalangium Liliastrum. 255.
Anthericum Liliastrum. H. K.

Hemerocallis flava. 15. H. K.

Hemerocallis fulva. 16. H. K.

HEXANDRIA TRIGYNIA.

Flagellaria indica. 257. H. K.

This genus is deemed by Mr. Brown of doubtful affinity in respect to Jussieu's orders of *Asparagi* and *Junci.* He thinks it nearer akin to the latter. By Jussieu it is placed among the former; but with a mark of doubt if not nearer to the *Junci.*

Tofieldia palustris. 256. H. K.

Tofieldia pubens. H. K.
Tofieldia pubescens. 324.

Melanthium gramineum. 249. *Persoon's Synopsis Plantarum.*

A species found on the coast of Barbary; also in Syria. It seems to us to stand in the same relation to *Colchicum*, as *Galaxia* does to *Crocus*; and to commence the transition from an under-ground to an above-ground supported inflorescence.

Medeola angustifolia. 393.

Medeola asparagoides. 442.

Neither of these species are near enough to *Medeola virginica*, the type of the genus, to be included with it, and must be separated.

Trillium erectum. H. K.
Trillium rhomboideum. 134.

Trillium sessile. 133. H. K.

Colchicum variegatum. 238. H. K.

Colchicum alpinum. 467.

Colchicum autumnale. 468. H. K.

Colchicum autumnale. 228. H. K.

Colchicum Bulbocodium. B. M. 1028, *in specierum Synthesi.*
Bulbocodium vernum. 197. H. K.

Colchicum montanum. *Willdenow's Spec. Plant.*
Merendera Bulbocodium. 25.

Helonias bullata. 13. H. K.

Helonias lutea. H. K.
Ophiostachys virginica. 464.

Helonias viridis. B. M.
Veratrum album. 447.
Veratrum viride. H. K.

Helonias nigra. *nobis.*
Veratrum nigrum. 416. H. K.

Helonias glaberrima. B. M.
Zigadenus glaberrimus. 461. Michaux Flora boreali-Americes.

A drawing done from a dried plant. It may be of a plant distinct from that in the B. M., although we suspect not; but at all events it is a good *Helonias.*

HEXANDRIA POLYGYNIA.

Alisma Plantago. 452. H. K.

Alisma ranunculoides. 268. H. K.

Alisma natans. 285. H. K.

Alisma Damasonium. 289. H. K.

OCTANDRIA TETRAGYNIA.

Paris quadrifolia. 226. H. K.

ENNEANDRIA HEXAGYNIA.

Butomus umbellatus. 209. H. K.

Pleea tenuifolia. 248. *Persoon's Synopsis Plantarum.*

GYNANDRIA MONANDRIA.

Neottia elata. 164. H. K.

Neottia speciosa. 404. H. K.

Malaxis lilifolia. H. K.
Ophrys lilifolia. 437.

Bletia florida. H. K.
Limodorum purpureum. 83.

Bletia Tankervilliæ H. K.
Limodorum Tankervilliæ. 43.

Cymbidium ensifolium. H. K.
Epidendrum sinense. 113.

Cymbidium aloifolium. H. K.
Epidendrum aloifolium. 114.

Epidendrum ciliare. 82. H. K.

Epidendrum cochleatum. 346. H. K.

Epidendrum bifidum. 84. *Willdenow's Spec. Plant.*

There is no mention of this species as having ever been in any English garden.

GYNANDRIA DIANDRIA.

Cypripedium Calceolus. 19. H. K.

Cypripedium pubescens. H. K.

Cypripedium flavescens. 20.

MONŒCIA HEXANDRIA.

Sagittaria sagittifolia. 279, 280.

Sagittaria ovata. 411.

We suspect this is not distinct from *Sagittaria lancifolia,* of Curtis's Botanical Magazine, 1792.

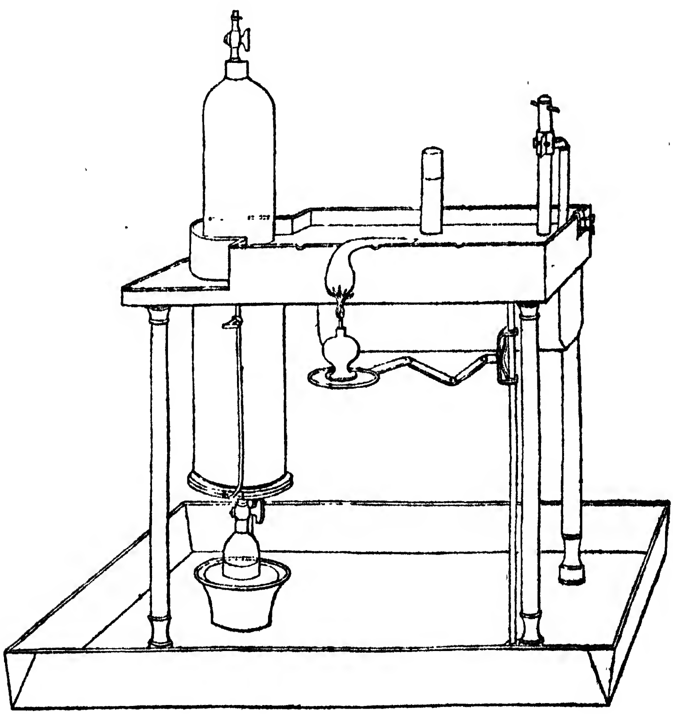
POLYGAMIA MONŒCIA.

Musa coccinea. 307, 307. H. K.

Musa paradisiaca. 443, 444. H. K.

The concluding fasciculus, containing six figures, has not yet reached us.

ART. V. *On a new Mercurio-Pneumatic Apparatus. By Mr.* JOHN NEWMAN. *In a Letter to the Editor.*



SIR,

I HAVE taken the liberty to submit to you the description of a mercurial apparatus, in which I have endeavoured to combine the advantages of

different instruments, and facilitate the performance of experiments on gasses absorbable by water.

The great weight of quicksilver renders a mercurial trough extremely inconvenient, when its size is such as to permit of transferring between moderate sized vessels; and if, in order to avoid this circumstance, the apparatus is made on a small scale, it necessarily limits the gasses worked upon to minute quantities, and often renders experiments uncertain.

To obviate, in part at least, these inconveniences, Mr. Clayfield and Mr. Pepys have invented very excellent mercurial gazometers, where, with a small weight of quicksilver, a considerable quantity of gas may be collected, and such gas may very readily, by means of tubes and stopcocks, be conveyed to other similar gazometers, or to exhausted vessels.

My object has been to join a gazometer of this kind to an improved mercurial trough, by which means the advantages of collecting large quantities of gasses, of working under a large surface of mercury, of transferring, &c. are obtained with the least possible quantity of metal.

The appartus requires between 60 and 70 pounds of mercury to fill it, the trough has a cavity in the middle large enough to fill a jar 10 inches long and 2¼ wide, and there is a shelf on each side 3 inches in width, to support vessels containing gas. Opposite to three indentations, on the edge of the trough, are three holes in one of the shelves, into which the beaks of retorts liberating gas are to be introduced; or a sliding shelf with apertures may be fitted across the cavity in the middle, for the same purpose. The gazometer is at one end of the apparatus, and sunk beneath the level of the trough: it is nearly as capacious as Mr. Pepys's, containing 50 cubical inches.

As the general application and uses of this gazometer are well known, I shall only describe such parts as I have added, to render it useful in conjunction with the trough, and to permit of transferring gas from it to receivers standing upon the shelves; a tube, connected with the gazometer at the lower part, is made to ascend, and passing up through the mercury in a corner of the trough, at about an inch above it,

bends down again and terminates beneath its surface. If gas is contained in the gazometer, it may be transferred to air jars in the trough by filling them with mercury, placing them over the end of this bent tube, and giving pressure to the gazometer, the air will pass from the gazometer along the tube into the jar. By the bend in the tube, the mercury is prevented from passing into the lower part of the gazometer, whilst, at the same time, the gas is allowed a free passage; as, however, if the lower part of the tube should by accident become filled with mercury, it would act as a syphon and occasion inconvenience, care has been taken to prevent that by a stopcock, which shuts off the communication between the receiver and the trough, preventing at the same time the escape of air from the gazometer, and of mercury into it.

A sliding shelf is fixed beneath the trough to support a spirit lamp under a retort, or for other purposes: a detonating tube and spring are also attached to the apparatus by a clamp and screws, and may be fixed on any side of the trough.

The whole apparatus is of iron, excepting sometimes the pillars which support it, and which may be of brass; it is not more than 18 inches in length and height; it is placed in a large japanned iron tray, to collect scattered mercury; its appearance is neat. I have made many of them for public institutions, and they have always given great satisfaction.

I am, Sir,

Your obedient Servant,

Philosophical Instrument Maker, JOHN NEWMAN,
Lisle-street.

Art. VI. *Account of a Soda Lake in South America. By M.* Palacio Faxar. *Transmitted to the Editor by* Charles König, *Esq. of the British Museum.*

In Maracaybo, one of the provinces of Venezuela (48 miles east of Merida, about 8 degrees of N. L., and 70 degrees some minutes of W. Lon.), is a valley, called by the natives *Lalagunilla,* the small lake. On the south of this valley, which contains an extent of country seven miles in length and five in breadth, runs that branch of the Andes which extends along the coast of Venezuela, and rising on this spot to the line of perpetual snow, forms La Sierra Nevada of Merida.

The waters that descend northwards from La Sierra unite to form the river Chama, which traverses the neighbouring countries, Mucuchies, Merida, Exido, Lalagunilla, and Estanques, and loses itself in the woods which surround the lake of Maracaybo. Those, on the contrary, which descend southwards from the Cordilliera are received by several rivers communicating with the Apure, which falls into the Oronoco. At a considerable height northwards, on La Sierra, is found the species of Cinchona, known in commerce by the appellation of Cinchona of Carthagena.

The north side of Lalagunilla is bounded by a limestone hill. The land rises imperceptibly towards the east and descends gradually several fathoms towards the west, until it reaches that tract of country which produces the Cacao (cocos butiracea). The bed of the valley is formed of chalk; it is situated about 250 fathoms above the level of the sea.

The village of Lalagunilla is situate in the south of the valley; its inhabitants, a strong laborious people, are Indians, whose only occupation is agriculture and the extraction of the *Urao.*

Nearly in the centre of the valley is the lake which receives the rain water that descends from the neighbouring mountains; but as even during the greatest drought the lake never becomes dry, it is supposed that it has some springs which supply it with water, independent of the rains. Its dimensions

in the rainy season, in the widest part, are two hundred and ten fathoms by one hundred and six. On the eastern side, where the waters are deepest, its depth never exceeds three fathoms. To prevent inundations to the neighbouring cottages, a drain is cut on the south-east side, which carries the waters into the Chama. On the eastern side the waters are very shallow, and being contracted in width, give to the lake a somewhat oval form. It is on this side that many aquatic plants are found. The air of the valley being very dry, the climate mild, the sky serene, the country in a high state of cultivation, and the view of La Sierra Nevada truly sublime, a residence here is delightful, and many families from Merida and the environs constantly pass some months of the year at Lalagunilla.

The waters of the lake are impregnated with carbonate of soda, which crystallizes in the dry season, and is in that state by the Indians called *Urao*. The extraction of this salt, which is employed at Venezuela to prepare the Mò or inspissated juice of tobacco, has been long known and practised at Lalagunilla. At the end of the last century, when the Court of Madrid monopolized the cultivation of tobacco, the right of extracting the Urao fell likewise to the crown. On the east side of the lake a magazine was erected for receiving the Urao, and another building as a residence for the *Teniente visitador*, or captain of Gens d'armes, in whom was vested the government of the lake, with a view to prevent a species of smuggling which the Indians are much inclined to practise, by secretly withdrawing the Urao.

The water of the lake is of a yellowish green colour, of a saponaceous quality, alkaline taste, and peculiar smell. There is no appearance of fish of any kind in these waters; the only living creature I could observe was an insect on the borders of the lake, which appeared to me a species of spider.

These waters having a strengthening quality, convalescents resort thither in the morning to bathe, and derive great benefit from them in some cutaneous diseases. In many disorders incident to horses they are likewise very efficacious.

When the period for the extraction of the Urao arrives, which is every two years, those Indians of Lalagunilla, who are devoted to this employment, and who are called Huragueros, are embodied at the residence of the Teniente visitador. The Indians employed at this work are easily distinguished, by their hair becoming red. Being embodied, they proceed, in presence of the Gens d'armes, to sound the lake with a long pole, at the end of which is fixed a bar of iron, which serves to break the mineral. Having by these means found the parts where the Urao is most copiously deposited, they divide themselves into different parties (quadrillas), for the sake of facilitating their labour. Each party, composed of eight, ten, or more Indians, fixes a pole in the centre of the district allotted to them. Supported by this pole, the Huragueros plunge into the lake, and beginning by separating a bed of earth which covers the mineral, they proceed to break the Urao. When they suppose that a considerable part of the Urao is separated from the mass, they dive for it, and then rising again above the water, place it in very small canoes (piraguitas), which float round the spot. As there are several Indians which explore the same mine, the work goes on without interruption, but the same Huraguero is not able to plunge many times successively. The work, which begins early, and always in presence of the Gens d'armes, who are stationed on the borders of the lake, ceases at six o'clock in the afternoon, when the produce of the day's labour is deposited in the royal magazine, and is afterwards exposed to the heat of the sun.

The extraction, which lasts nearly two months, produces from 1000 to 1600 hundred weight of Urao, which is the quantity consumed in two years at Venezuela, but if more were required the lake would probably furnish upwards of four times that quantity. The difficulty of extracting the Urao may easily be imagined, but what is much worse, considerable danger attends it. If the Indian diver happen to lose his hold of the pole, or if some other accident prevent his rising promptly to the surface of the water, and indeed, the

Indians of Lalagunilla are in general but indifferent divers, he is in danger of swallowing more or less of the alkaline solution. If the quantity drank be inconsiderable, the bad consequences may be trifling; but if he happen to drink largely, he cannot survive it many days. Oil has been had recourse to in vain. Acetic acid might, perhaps, in such cases be administered with better effect. Father Rendon proposed, in 1808, to the Captain-general of Caraccas, to effect the extraction of the Urao by sinking a caisson, which when properly secured should be opened at bottom to get at the soda. This project, which undoubtedly at low water might be realised at a small expense, was rejected as impracticable.

When the extraction of the Urao is completed the superintendant of the tobacco, who resides at Merida, repairs to Lalagunilla, accompanied by the Teniente visitador and others. The salt is weighed, and paid for in the proportion of about one real of plata (about seven-pence) the pound. It is then veyed into the general storehouse for tobacco at Guanare, in the province of Caraccas, whence it is distributed to the lesser warehouses.

If a heap of tobacco leaves covered with the green leaves of other plants be exposed to the sun for a few days, the tobacco begins to ferment. If then put into a press a red liquor may be drawn from it, the exhalations of which are intoxicating, and its taste very pungent. This juice drawn from the tobacco is called Anvir, but when reduced to a syrup, by evaporation, it is termed Mò. If the Mò be mixed with the Urao when dried, roasted, and pulverised, it forms the Mò dulce, if the proportions be preserved of an ounce of Urao to a pound of Mò, or otherwise Chimò, if two or more ounces of Urao be mixed with a pound of Mò.

In the province of Venezuela, and especially in Barinas and part of Caraccas and Maracaybo, Mò is much used and likewise Chimò, which is kept in small horn boxes, and occasionally persons put a little into their mouths. The Mò, and especially the Chimò, produces a copious salivation, stimulating at the same time the nervous system, which in these climes,

where the senses are blunted by the excessive heat, is productive of a degree of pleasure.

It is likewise used in medicine for spasmodic complaints, which in these countries are both frequent and dangerous. It is said that a little Chimò held in the mouth protects swimmers from the electric power of the cramp fish (Tembladores.)

The sale of tobacco, the Mò dulce, and Chimò, in the Captaincy-general of Venezuela, produced, in 1804, 700,000 piasters after every expense attending it was paid.

I had the honour of transmitting last year to Baron Humboldt in Paris, a specimen of the Urao, which Colonel Duran brought to Europe. It was analysed by M. Gay Lussac, who pronounced it to be natron, in no respect different from that found in the lakes of Egypt and Fezzan. The mass neither contains sulphuric nor boracic acid, but a little subcarbonate of ammonia. On comparing the Urao with common subcarbonate of soda we find that it contains more carbonic acid and less water.

In the environs of Lalagunilla, as well as in the roads to Merida, and especially near the river Albarregas, there are some mountains which are very distinguishable among the others by their superior verdure, and by the abundance of some plants, principally the Rosa de Muerto, and precisely the same species of verdure and the same plants are found on the mountains where are the mines of rock salt at Zipaquira, and at Enemocon of Cundinamarca in New Granada. Finding these similarities, I may venture to form a conjecture that in the environs of Lalagunilla there must likewise exist muriate of soda, and this being ascertained it would perhaps contribute to explain the formation of natron at such a considerable height above the level of the sea, which is more than sixty leagues distant from Lalagunilla.

Art. VII. *Description of a new Construction of the voltaic Apparatus. By* W. H. Pepys, *Esq. F.R.S. M.R.I. &c.*

It must have occurred to those engaged in a series of voltaic experiments, to observe the early exhaustion of power and the inequality of the action under the usual construction and management of the apparatus. The lecturer on this subject has more particularly felt such inconvenience; as during the progress of his experiments of elucidation he is obliged frequently to pause for explanation, during which time the power is on the decline.

To obviate these difficulties, I constructed a table, with drawers containing a suite of troughs, all the plates of which might be either raised out of the acid, or immersed into it, simultaneously. By means of a lever and counterpoise weight, the whole of the plates were as easily elevated as one series; all the communications with the prime conductors being, as in my voltaic discharger, completed by quicksilver.

It might, perhaps, be difficult, or impossible to arrange the extensive batteries of the Royal or London Institutions upon this plan; but for all the experiments where very powerful combinations are not wanted, the present instrument is excellently adapted, and its action remains uniform during any series of comparative elucidations. The whole arrangements of the auxiliary apparatus, and every other preparation may be completed before the power is laid on, and, when required, it can as instantaneously be stopped.

I have found it a very useful combination in experiments on animals, on the decomposition of fluids, and solutions, in the transferring experiments of Davy, or the combustion of metallic leaves, and on the changes in vegetable colours.

The troughs being enclosed within the table or chest, prevents the free escape of the acid vapours; and where an opportunity offers of communication with a chimney or window, a pipe may be usefully added to carry them off..

From the observations I have made, I conclude that at each

immersion of the plates the action commences, arrives at its maximum, and gradually diminishing, almost ceases; therefore the present construction has the greatest advantages, as an equal state of excitation must exist in each trough in consequence of the simultaneous immersion of the plates.

The apparatus was skilfully completed under my direction, by Mr. Bate of the Poultry.

W. H. PEPYS.

Explanation of the Plates.

Fig. 1. The external figure of the case.

Fig. 2. The internal arrangement of the whole contents (except the communications), the front being removed.

Fig. 3. Side view of the same contents, the side of the case and drawers being removed.

Fig. 4. One of the drawers, with the spring supports, or props for the plates.

Fig. 5. Front view of the communications.

Fig. 6. Side view of ditto.

The Voltaic Series consists of sixty pair of plates, four inches square, each plate presenting its whole surface to the action of the acid; they are arranged in two drawers A, A, one above the other, each drawer containing three porcelain troughs a, a, a, and each trough ten pair of plates b, b, b; the plates are suspended from rods c, c, c, connecting each set of ten pair together, and these rods drop into a square frame d, d, made to the full size of each drawer inside: the action of these frames lowers or raises the whole of the plates together, and is thus contrived.

B, B, are two rods passing through the upper board or table, and resting upon the short arm of the levers C, C, Fig. 2, which are of wood; these rods have each two pair of pins e, f; e, f; and which in Fig. 2 are represented as employed, the plates being in action; but in Fig. 3 the contrary, the lower drawer being open, and the frames, with plates supported by their props D, D. The drawers being first shut, the handles E, E, of the rod B are to be turned inwards, as in Fig. 2, when the pins e, e, enter the openings cut in the sides of the drawers at g, Fig. 4, and stop in the grooves h, h, Fig. 2,

cut in the square frame d, to receive them; in the meanwhile, the shorter pins f, f, bearing upon the lower sides of the spring props D, press their upper end or points entirely within the thickness of the drawer on each side, and release the frames d, d The whole weight of the plates now bearing only upon the rods, is counterpoised by the weight w, which connects the two levers C, C; they are gradually let down into their several partitions, and the action of the battery commences; at the conclusion of the experiment the rods are again raised by the handles E, E, and when stopped, the pins e having reached the top of the groove g, Fig, 4, the handles are to be turned back into their former position, as in Fig. 3: the props D, being now first released, shoot into the drawers, and support the frames when the pins e, e have quitted them.

The communications between each trough are effected in the usual manner; but those which conduct the fluid from one drawer to the other, and from the opposite ends of the series to the upper board or table, are capable of being disengaged, and their connections are effected under mercury, as in the voltaic discharger.

They are thus arranged; i, i, i, are ivory cups containing mercury, and fixed to the drawers; j, j, j, are platina wires depending from them, and entering the troughs; k is a ring and wire, which effects the communication between the two drawers; and l, l, are the two wires which conduct the fluid from the opposite ends of the battery to the table, C being the copper, and *Z* the zinc end of the series.

Art. VIII. *Some Remarks on the Arts of India, with miscellaneous Observations on various Subjects. By* H. Scott, *M. D.*

During a long residence in India, I communicated to Sir Joseph Banks some observations that I had made on the arts

of that country, and I intermixed occasionally some speculations of my own. He kindly sent replies to my letters, and took a very active part in endeavouring to promote several of their objects.

He lately told me that a part of my communications had not been without effect, while others had made no progress. Men slowly alter their habits, and receive, perhaps wisely, whatever is new with reluctance and distrust.

Among the new objects to which he referred as having done some good, he mentioned to me the Wootz, or Indian steel. This steel is now acknowledged to be of an excellent quality, and better fitted for some purposes than any other yet known. After many ineffectual attempts to work it, it is now made into surgeons' instruments, razors, &c.

He next mentioned the operation for the restoration of the Nose, which has been performed in this country in consequence of a communication of mine to him. My letter was plundered of its contents, and before it reached him the publication of that part of it which regarded the nose was made in the Gentleman's Magazine for 1794. The account that I there gave of the operation was republished by M. Tennant, with some most extraordinary opinions of his own. I believe that Mr. Carpue will acknowledge, that without the assistance of my communication he never would have ventured on the bold operations which he so happily performed, acquainted as he might be with the method of the Italians and the ample volume of Taliacotius. In all this I claim little merit, farther than that of being the first person to give an intelligible account of an operation that cannot have been quite unheard of by my countrymen in India for many years past. On this occasion and many others I have thought (if we are to judge from experience), that it is as difficult to detect and to appreciate the practice of a simple art in India, as to discover a law of nature.

Among the things too that have made some progress in society, Sir Joseph mentioned the nitric acid; concluding the conversation with requesting me to publish an account of some of the facts that I had detailed to him on various

subjects. With regard to arts so ancient as those of India, he thought that a knowledge of them would afford at least some gratification to rational curiosity. In compliance with this desire, I shall detail in as few words as I am able some parts of the correspondence to which I have alluded.

I mean in the present paper to confine myself chiefly to a detail of some of the effects that I have observed from diluted nitric acid taken internally, and used as a bath for a variety of diseases. The field is far too extensive to be well surveyed by me, or indeed by any one individual, and I must rest satisfied with a very general sketch. Though conscious of being quite unequal to the task, I am carried on by the belief that no other person has yet had the same means of judging, and from the conviction that by the "*harmless remedies that I now recommend much good may be done in some diseases that are acknowledged to be beyond the ordinary means of relief.*"

It is well known that climate alters much the phenomena and the nature of the diseases to which the human body is liable. A great part of my life has been spent between the tropics, where the temperature is generally high, where the vegetable world in its genera and species puts on appearances that are quite new to the inhabitant of Europe, where the animals are generally very different, and where the diseases by which they are afflicted arise from other causes and with different symptoms. I have often thought that it would be curious and useful to mark, from sufficient experience, the peculiar maladies to which we are subject in a hot climate, as well as those from which we are exempt. If this were done with skill, it might give rise to a number of important conclusions both for avoiding and curing diseases.

Cancer is nearly unknown within the tropics. During twenty-five years I saw one case of cancer in a person who had brought the rudiments of the disease from Europe. From that case I learned the afflicting truth, that although a hot climate does generally prevent the formation of cancer, yet, when once it is formed, it does not cure it. I saw, in another instance, a cancer arise in India with an European Gentleman, from often pulling the hairs

from a wart on the skin of the cheek, and which produced at last the most deplorable effects. If such a complaint had appeared in any natives of the country, whatever might have been their cast or condition, I should probably have seen or heard of it.

Phthisis pulmonalis is not common in that climate, although it does occasionally appear. The true Phthisis is certainly a rarer disease there than many European practitioners suppose, for the lungs very often suffer from abscess and affections of the liver; and it is no easy matter to distinguish such complaints from the true phthisis pulmonalis.

Scrofula is rare, though particular causes do sometimes produce it. Cold and moisture seem to be the great sources of the scrofulous diathesis, for the children of Indians, and even the ape kind, although free from the disease in their native climate, are very liable to scrofulous affections on being brought to Europe. Would it not appear then, that similar causes have a tendency to produce phthisis pulmonalis, scrofula, schirrhus, and cancer, and that there is some connection in their origin, and perhaps in their nature?

I never knew an instance of a biliary stone being found in the gall bladder or the biliary ducts, in India.

The formation of stone in the urinary bladder is nearly unknown between the tropics. I have indeed not met with a single instance of it, although I have known some cases where such a disease was imported and not removed, by climate. This exemption, however, from those dreadful diseases does not extend through a great extent of latitude; and it should also be remembered that altitude above the sea has similar effects to a more northern latitude. I speak of my experience in a country on a level nearly with the ocean, and having a barrier of ghauts or mountains towards the east. In the northern parts of India the maladies of Europe begin to shew themselves. I knew a boy who got a stone in the bladder in Guzurat, for which he had been cut by a native surgeon. The perforation was made in nearly the same place that it is in Europe, and the operation was what is called, I think, by the *Gripe*.

I may take notice here of a case of stone in the bladder (it cannot be too often mentioned) which was remarkable for the singular mode of cure adopted by Colonel Martine, himself the sufferer. He then resided at Lucknow, but I believe the Colonel had lived in many of the northern parts of Hindostan. I knew well a surgeon* of the Company's service, who was intimate with the Colonel, and visited him at all hours, and often saw him carrying on his process for cure. It consisted in reducing the stone to powder, by a fine saw introduced through the urethra by means of a canula, and he perfectly succeeded in removing the whole of it. The Colonel was an ingenious mechanic. His saw was made of the steel spring of a watch. He introduced the canula till it touched the stone, and then, by changing the position of his body he pushed on the saw till it was, for a little way, in contact with the stone, and then moving it backwards and forwards, he reduced it to powder. My friend often saw him at this work, and occasionally more than once on the same day. The operation gave him no pain whatever, for soft parts plentifully covered with mucus, are under very different circumstances from hard and resisting bodies, and completely elude the teeth of so fine a saw. Soon after every sawing, he passed with his urine a quantity of the stone in the form of a powder. Although a parallel case will not often occur, where the patient is so intelligent and ingenious, and the final success so decisive, yet by long habit and guided by feelings known only to the individual, I should hope that a similar mode might *sometimes* be applied with advantage. No surgeon can effect this for another person. To place the stone and the saw in the proper positions, and to carry on the operation with success and without pain or injury, can only be done by the patient himself. The hopes of relief, the attentions and the observations necessary to attain it, the repeated trials, with all the sources of employment and of comfort to a miserable man, may well reward him, even if the perfect success of Colonel Martine should be unattainable.†

* Mr. Bright.

† Since writing the above I have conversed with a very intelli-

Although a tropical climate does not at all times prevent the attacks of gout, yet they certainly are less common and severe than in cold countries.

Acute rheumatism is rare between the tropics, but cases of it do occasionally occur. In like manner, the chronic kind is sometimes met with in India, and is more easily cured than in Europe.

While the glands, that are the common seat of scrofula, are less generally diseased between the tropics than here, other glands suffer there more frequently than in Europe, and in particular the liver and spleen. I have fancied at times that I could see mechanical causes for some of the derangements of the liver in a hot climate. The resinous matter of the bile seems to be there more abundant. It appears occasionally to separate from its union with soda, when it stagnates in the liver and enlarges it, giving rise to all the phenomena of chronic hepatitis. By some means the calces of mercury stimulate that organ, or they give solubility to this resinous matter, which then passes through the ducts to the intestines. Such a bilious discharge, from the use of mercury, is the true signal of relief When from long illness or other means weakness is produced, with a languid circulation, chronic hepatitis is almost a certain consequence. The vis a tergo in the liver is diminished, depositions take place, and I have seen after death resinous and spermaceti-like matter choaking and obstructing the ordinary course of the circulation, and greatly enlarging the whole mass. It is said, that in some parts of Germany the overgrown livers of geese and ducks are esteemed

gent officer of high rank, who knew the Colonel intimately. He tells me. that the instrument for reducing the stone to powder was rather a file than a saw, and that it was fixed to the end of a piece of whalebone. It was passed into the bladder through a canula. So accurately from habit could the Colonel judge of every circumstance, that he could tell when any part of the surface of the stone became more elevated than the rest, and could remove that part with the greatest nicety. On speaking to a friend now in town, who also was intimate with the Colonel, he was told, that the filing part of the instrument was made of a knitting needle, properly tempered for the purpose.

a great delicacy for the table. In order to produce them, they fix the animal by the feet to a board; they keep it motionless in a high temperature, and force it to swallow a great deal of nourishment. This is the case occasionally with our countrymen in India; a high temperature, little motion, with a plentiful diet; and the very same consequences make their appearance. While a very languid circulation of the blood gives birth with certainty to chronic obstructions of the liver, acute hepatitis, on the contrary, is produced by all those causes which quicken the circulation beyond its proper rate. Such are violent exercise, fever, and hard drinking, and, I might add, steel, and tonics, and bark. From the peculiar structure of the liver, and the state of the circulation of its blood, it cannot flow much more quickly than is natural with impunity. How often are boys seized with a pain in the region of the liver, after running with rapidity?

The calces of mercury do certainly give the utmost relief, both in acute and chronic hepatitis. While in the acute kind we employ between the tropics the antiphlogistic plan, blistering, blood letting, and especially purgatives, we ought not for a moment, if the disease is severe, to delay the use of the calces of mercury internally, with the ointment externally, as being of more consequence than all the other means in our power. No condition, to which human nature is exposed, is more deplorable than that where an abscess has taken place in the liver. I know of no sufficient security in that climate against such an evil but mercury. As soon as the mouth gets sufficiently affected, and the system is impregnated with it to a proper degree, the pain, the fever, and the distress abate, and the patient remains quite secure from the risk of abscess, provided we have not used the remedy too late, and when such a change has taken place as must necessarily end in abscess. While nobody is better acquainted with the inestimable benefits that arise from the due use of mercurials than myself, nobody can better know the ill consequences that follow them. In those predisposed to scrofula, they excite it; in those with a tendency to consumption, they accelerate it;

and they have other bad consequences that I need not mention. When, however, we are threatened with the formation of matter in the liver, we must neglect all those considerations, and submit to smaller evils, in order to avoid one of the most melancholy kind.

When in India, I was most anxious to discover a substitute for the mercurial calces, less injurious and equally efficacious, and I have not been entirely without success. I knew that the nitric acid acts most readily on the resinous matter of the bile, and I was in hopes that I might communicate such an acidulous state to the living body as should produce the effects that I desired. That it may alter the nature of the urine has been proved by Mr. Brande, who has recommended the use of it in a particular kind of urinary calculus. If large secreting glands are thus materially affected by merely drinking this acid, I cannot doubt but that by bathing the whole surface of the body below the head, in a very dilute nitric bath, much of it may be absorbed, and more material effects produced. I had found that through the medium of the stomach the effects of the acid, if given to the wished-for extent, might be injurious, and I had tried to little purpose to combine it with substances for which it has but a slight affinity, expecting by such combinations to diminish its action on the stomach without destroying its useful qualities. From its absorption by the skin, some effects have arisen that I think very important. We are destined to find our way by experience, and can never know to what an untried agent may lead us at last.

I gave, many years ago, a short account of my trials with the nitric acid in India. It was obtained there by means of alum from common crude Bengal saltpetre. In that country both alum and saltpetre are plentiful and cheap; but I could not obtain the sulphuric acid, unless from Europe, or by making it myself. In both cases it would have been expensive, from requiring either the payment of freight for a long voyage, or the expense of erecting a considerable apparatus. I was satisfied, therefore, with the acid procured, as I have

said, from unrefined saltpetre and alum. I was aware that that acid was far from pure. I knew that it was mixed with a considerable proportion of muriatic acid, derived from the muriates which that saltpetre so plentifully contains. I had long given this acid internally, and I had found it harmless, and sometimes very useful. I was far from thinking at that time, nor did I suspect till long afterwards, that pure nitric acid is unequal to the production of all the benefits which I sometimes derived from my acid applied to the surface or to the stomach. A suspicion of this kind first arose from circumstances that I must now explain, at the risk of being thought tedious. At that moment I lamented the impurity of my nitric acid, and I was sorry to use alum instead of sulphuric acid, although in the end both of those circumstances have been highly useful, by leading me to conclusions at which I never otherwise could have arrived.

At the Presidency of Bombay we have extensive works for gunpowder, from which the armies on that side of India, and occasionally the navy, are supplied with that material of war. The manufacture of this article had fallen into the hands of some Parsees, who, as in other cases, had some practical knowledge, but no kind of science, to direct them. Complaints of the gunpowder had become very general. It grew moist in the magazines, and did not, after keeping, answer to the common modes of proof. So very ignorant were those men, that they perpetually returned all the liquor remaining after the crystallizations of their salpetre on the next quantity to be crystallized. They judged their saltpetre to be sufficiently pure and fit for gunpowder when they saw the crystals clear and transparent, and free from charcoal or mud. After a committee of intelligent officers had reported on this state of things, I was desired to take charge of those works, which I continued to hold till my departure from India. By adopting the necessary measures, our gunpowder soon became as good as any in the world. One of those changes (and it is what leads me to the present digression) was the purification of the saltpetre. I had read in the "Annales de Chimie" a proposal

of M. Lavoisier to purify that article for gunpowder, by reducing it to powder and then washing it with two portions of water. These two washings were sufficient to dissolve nearly the whole of the deliquescent salts, with a certain portion of the nitre. This to us was not only a very effectual operation, but it was one profitable to the public, for by evaporating the liquor of the two washings we recovered a quantity of saltpetre, impure indeed, but when mixed with charcoal, &c. still fit for making fireworks for the celebration of the weddings of the natives. As during the state of warfare which prevailed at that time, it was judged proper to prohibit the importation of saltpetre for sale, the product of our washings was gladly purchased. After saltpetre has thus been carefully washed, it is perhaps free enough from saline impurities to be fit for gunpowder; but I have always given it one subsequent crystallization, fearing it might contain a little sand or other matter, by which a spark and an explosion might be produced.

Being at that time impressed with a belief that the effects of my acid on the human body arose entirely from the *nitric acid,* I thought it would be a great improvement if I distilled it, not, as usual, from the crude saltpetre, but from such as had been washed in the way I have mentioned. This practice I continued for a long time, and indeed until I left India. Since using this purer saltpetre, I have often imagined that some of its beneficial effects were no longer produced, or were less remarkable. But my means of observation were cut short, first by very bad health, and then by being obliged to leave India for this country. Until lately I had no opportunity of seeing the sick here, or of recommending remedies for them; but still the *suspicion* of my having diminished the power of the acid, by purifying the nitre, hung on my mind, and I resolved to put it to the test of experience, as soon as I might have it in my power. About seven months ago I came to London, and by the aid of some intelligent friends I have been able to ascertain facts that I think in teresting. I have found that the acid produces many effects in this climate as readily as it did in India. For the reasons just stated, I

have used in all my late trials not the nitric acid, but an acid composed of three parts of nitric and one of muriatic acid. With the result of these trials I have been sufficiently satisfied; nor have I had reason to think, that a constitution broken down by disease, by the use of powerful remedies, such as mercury, or by the long continued action of the poison of syphilis, receives less benefit in this climate from the acid treatment than I have derived from it in India.

I long ago said that I had removed syphilitic affections by the nitric acid (it was rather the nitro-muriatic), which had resisted mercury long and judiciously applied. I had combined the external with the internal use of the acid, and I succeeded in some of those cases at least, which have been called pseudosyphilitic. This state of syphilis is thought by some able and eminent men to be a new disease, and arising rather from the consequences of the remedy than from the poison of syphilis still existing in the constitution. I know well that an indiscreet, or even a large use of mercury, may give rise to much evil; but I may be permitted to say, that no skill nor prudence in the application of that remedy will at all times prevent the occurrence of pseudosyphilis. In it I believe that the poison of syphilis still exists, remaining occasionally dormant, and becoming, from unknown causes, active and injurious, and exerting again all its specific effects. I think, however, that the cause of pseudosyphilis is a scrofulous habit, acted upon at once by the poison of mercury and the poison of syphilis, for to such a habit of body they are both poisons. We cannot destroy the syphilitic virus without calling into action the scrofula, to which there is a predisposition, so that on the patient is entailed a new disease not less afflictive than either of those from which it arises. It may perhaps be thought some confirmation of this opinion, that during the whole of my residence in India, where mercury is so commonly, so largely, and sometimes so injudiciously given for affections of the liver, I never knew a single instance of this *new disease* having arisen where syphilis was *certainly* out of the question. That this sort of syphilis is very common in this country, is evident from the inspection

of many of our public hospitals, where patients are often seen, who for years together have been subjected to many courses of mercury, and a variety of useless or hurtful remedies. Even in our streets many sufferers in this way must attract the notice of every medical man. It is not enough to say, that the nostrums of quacks, and the treatment of empyrics, have produced such evils. I have observed, that cases do occasionally occur where the utmost skill of the present times is found to be quite ineffectual. I now earnestly recommend the nitro-muriatic acid bath for this disease, a means yet untried in this country. I see that the nitric acid is given internally by many practitioners in Great Britain, and occasionally, I am assured, with advantage. The knowledge of this would sufficiently reward me for all the trouble I have bestowed on the subject, and here I might rest satisfied; but I wish still further to advance the use and the utility of the remedy. Like the calces of mercury this bath affects the gums and the salivary glands, giving rise occasionally to a plentiful ptyalism. Though it reddens the gums, swells them, and renders them somewhat tender, it never produces that nauseous smell nor those fœtid ulcerations which arise from mercury; nor from the bath did I ever know the least injury arise to the teeth. If the gums are much affected from the bath, it is generally prudent to stop its use or to diminish the absorption, by exposing a smaller surface to it. If we go on with it too long, some inconvenience is experienced: a degree of restlessness takes place, and the patient says, that he does not feel himself so well as he ought to do. Beyond this point I have seen no degree of harm from this general and powerful agent, and even this disappears on discontinuing it for a short time. I know no other means that are capable of producing effects at once so salutary and so considerable, so free from injury, with so little inconvenience or disturbance.*

* In this climate it will be found convenient to bathe only the feet and the legs daily, or twice a day. For this purpose a wooden tub may be used. The water when acidulated with nitromuriatic acid should taste about as sour as vinegar, or it should be of such a strength as to prick the skin a little after being exposed to it for twenty minutes or half an hour.

If the acid be employed for syphilis or pseudosyphilis, either by the stomach or the skin, I should consider every trial as quite inconclusive where a ptyalism, some affection of the gums, or some very evident constitutional effect had not arisen from it. As with mercury, the system should be kept charged with it for a longer or a shorter time, according to circumstances. Mercury never could have obtained the character of a specific for syphilis if it had been managed as the nitric acid has been, if it had been generally given in quantities so small by the mouth as even to leave it in doubt whether it is capable of affecting the gums and stimulating the salivary glands. Why should not the nitric acid receive the same privilege and indulgence that is conceded to mercury? It is still a stranger in this climate, and on that account requires the more care and attention. There is nothing absurd in supposing that nature may have many substances in store capable of destroying or removing the syphilitic poison from the constitution: I say, then, in the spirit of the illustrious Bacon, "fiat experimentum."

When I have removed a disease by the acid treatment that was regarded as undoubtedly syphilitic, I have been commonly told at last that we must have been mistaken, for that *nothing but mercury can cure syphilis.* I wish we had some chemical test for the existence of this poison in the body, that we might have more of the evidence of our senses and less of the wanderings of opinion. One of the states of syphilis, the least doubtful, is that of recent chancre, and this, though of a bad kind, I have seen in about a week completely removed by the bath.

There are no researches so difficult as those which regard the human body and the changes connected with life. The capacity of few men seems to me to be well adapted for them. The chemist may repeat his experiments as often as he pleases, he may vary them till he obtain results on which he can rely. It is very different indeed with the physician. The doubts and the darkness that surround him are in comparison tenfold. After all, it may be with myself that the whole of the errors lie: for who can judge of himself? I can believe that a man

who is not of my opinion may be equally sincere with me. But the same appearances convey to each of us impressions of a very different kind. With such a person then I need not reason, and I will not dispute. I must ask him, as Rousseau did his antagonist, "What is there, sir, in common to you "and to me by which we may be enabled to understand each "other?"

I employed while in India the nitric acid by the mouth or as a bath for various complaints, as I never wished to confine it specifically to any one. I was anxious to get from experience a general rule for its application, and it was certainly not without some success that I used it for several diseased conditions of the body. I shall slightly mention a few of those complaints in which I have found it of advantage. For some affections of the skin I have derived benefit from the bath; it rapidly and effectually removes every sort of sores. This bath has the advantage of keeping perfectly unaltered for any length of time, not suffering decomposition like water, and never emitting any kind of unwholesome effluvium. It is an agent that we employ with almost any degree of power. In those very weak and delicate I have plunged one arm into it only, or I have washed a portion of the skin with it. I have very often exposed the legs up to the knees in the bath, and by their means alone have been able to keep the mouth affected for a long time. When a greater power was required I have exposed the whole surface below the head to it. To all this may be added its internal use, if necessary.

Where the constitution has been weakened by fever or long continued disease, I have found in the nitric acid bath a tendency to renovate. It remarkably improves the complexion. In chronic hepatitis and a bilious disposition I have used it with much advantage. I have seen the happiest effects from it in apthæ of the mouth and intestinal canal, where every other remedy had failed. This is sometimes a dreadful disease in India; is it the "cachexia apthosa" of Dr. Latham? In many disorders of females, and in men worn out with obstinate intermittents, I have found it very useful. In short (and as a general rule), I have found the acid bath advantageous and

salutary in all cases where mercury is useful, and with the additional advantage, that the acid treatment is attended by neither injury nor inconvenience.

As I had seen the good effects of nitric acid in pseudosyphilis, or that kind of syphilis that cannot be cured by mercury; and as I had long thought that pseudosyphilis arose from syphilis in some way combined with scrofula, I became anxious to know the effect of the acid treatment in pure scrofula. Since I came to London I have seen a number of trials made by different medical practitioners with the nitro-muriatic acid. Some of these cases were of long standing, and of the worst kind. The result on the whole has been very favourable, though none of the patients have yet used it for three months. In almost all the health has improved, and some of the sores have healed, or show a tendency to heal. I have not seen a cure effected in a single instance; but this could hardly have been expected; for where the disease is of long standing, as with these patients, and where many glands are inflamed and enlarged, it is evident that a long time will be required to reduce them to the healthy state. I have seen remarkable relief in several people where the neck was much affected, much swollen, with many glands in a state of suppuration, so as to make the least motion painful and nearly impossible. In some of these the pain and swelling has much diminished, and a considerable degree of motion of the head is attainable without pain. In one girl in particular, who was reduced to a dying state, by merely drinking the acid, her health and strength have greatly improved, and the sores have healed or shewn a tendency to heal. With experience so short and imperfect, I cannot venture to say more, than that it holds out a hope of relief for some states of that cruel disease.

I have just seen Mr. Carmichel's book on Scrofula, which contains some just observations; and he seems to prove, that a disorder of the digestive organs is often connected with it. The utility of the practice that I have mentioned is very consistent with his idea of an acidity prevalent in the primæ viæ, for the mineral acids are known power-

fully to counteract such a tendency, by giving tone to the organs of digestion. This disease has been the source of gross empyricism; for at different times almost every product of nature or of art has been extolled for the cure of it. The boasted baths of the Greeks and Romans could produce little farther effect than what arises from hot or cold water, and are often nothing more than the mere semblance of doing something.

Of all the remedies for scrofula, those substances that contain chlorine *seem* to have been the most successful. Such are sea-water, sea-air, the muriates of lime, &c. &c. Sir Humphry Davy has shewn in a very late paper, that the nitro-muriatic acid (the aqua regia of the old chemists) is not a mere mixture of nitric and muriatic acids. On the contrary, from their union a quantity of pure chlorine is evolved, and water and nitrous acid gas (the results of the new affinities) are produced. Is chlorine a material agent in my bath? if I were sure of this I might mix the acids, so as to produce it still more abundantly. It has always been observed that calomel and corrosive sublimate are the most active preparations of mercury, perhaps from the chlorine held in the compound. Chlorine is now known to be an elementary body of the greatest activity, of the powers of which over diseases we are nearly in total ignorance.

I have for many years past given euchlorine for several diseases combined in its nascent state with soda. It contains oxygen very abundantly, and in a loose state of chemical combination. I meant it as a substitute for the nitric acid, and it is a very good one. Although Sir Humphry Davy had not at that time shewn us the composition of euchlorine, I saw that I was in possession of a valuable substance, which I have never since ceased to use. Mr. Brande has had the kindness to prepare for me portions of this compound, and he has shewn me an easier and a cheaper method of making it for common use, than the one which I was in the habit of employing. But I must defer what I have to say of this substitute for the nitric acid to another time.

I have thus concluded what I intended to communicate on

a subject of great importance. I have recommended from experience the practice of charging the body with some of the mineral acids or their elements for various states of disease, by the stomach, and especially by the skin. I may be weak, or I may be wrong, but I have acted from conviction; and I cannot but hope that an abler mind and a happier day, will yet confirm and extend the truths that I have but slightly touched upon.

"Alter erit tum Tiphys!"

H. SCOTT.

38, *Russel-square, May* 8, 1816.

ART. IX. *Account of an Hydraulic Machine for raising Water, called the "Water Ram."* *By* JOHN MILLINGTON, *Esq. In a Letter to the Editor.*

AMONG the various necessaries of life, nothing is more conducive to the health and comfort of mankind, than a plentiful and regular supply of water for domestic purposes; but this convenience is often withheld from those who live at a distance from towns, or the usual machinery for supplying water, notwithstanding they may possess it abundantly in their neighbouring springs or rivulets, which, from their low situations, preclude the possibility of using or obtaining it in any other way, than by actual transportation in carts or buckets. The expense of erecting horse-pumps or steam-engines is too great to admit of their general use in individual establishments. With a view to obviate these difficulties, and add to the comfort of those who may be deprived of the luxury of water, I beg to send you an account of a very simple self-acting engine, which is but little known in this country, though it has been several times beneficially used in France; and from the simplicity and certainty of its action, I am sure it only requires to be known and adopted to be approved.

The *belier hydraulique*, or water ram, as this machine was

called by Mongolfier, who first constructed it about 1797, is applicable to any situation in which there is a fall of a few feet of clear water, and drainage to get rid of the superfluous quantity: and as it is simple and cheap in its construction, and requires no attendance after it is once adjusted and set to work, it is particularly applicable to the supply of houses or gardens, and pleasure grounds situated upon elevations.

The action of the water ram, as will be seen in the following description of it, is entirely dependent upon the momentum which water, in common with all other matter, acquires by moving; a circumstance which has often proved very detrimental and troublesome to plumbers and others, in fixing pipes connected with elevated cisterns.

It may have been observed by many, on turning a cock attached to a pipe so circumstanced, that the water flows with great violence; and upon shutting it off suddenly, a concussion is felt, the pipe is shaken, with a noise resembling the fall of a piece of metal within it, and the pipe is not unfrequently burst open near its end. This arises from the new energy which the water has acquired by being put in motion for a short time and then stopped, in consequence of which it makes a considerable mechanical effort against that end of the pipe which opposes its further progress.

This effect was experienced in a great degree at an hospital in Bristol, where a plumber was employed to fix a leaden pipe to convey water from the middle of the building to the kitchen below, and it was found that nearly every time the cock was made use of, the pipe was burst at its lowest end; after making many attempts to remedy this evil, it was at last determined to solder a small pipe immediately behind the cock, which of course was carried to the same perpendicular height as the supplying cistern, to prevent the water running to waste, and now it was found that on shutting the cock the pipe did not burst as before, but a jet of considerable height was forced from the upper end of this new pipe. It therefore became necessary to increase the height of the pipe, to overcome, if possible, this jet, and it was carried to the top of the building, or twice the height of the supplying cistern; where,

to the great surprise of those who constructed the work, the jet still made its appearance, though not in such considerable quantities; and a cistern was placed at the top of the house to receive this superfluous water, which was found very convenient, particularly as it was raised without trouble or exertion.

This is, I believe, the first water ram which ever had existence, the circumstance having taken place prior to Mongolfier's contrivance, though he is the first person who organised the machine and made it completely self-acting, without ever turning a cock. His construction is represented in the Plate, where A is a cistern (or part of a running brook which may be dammed up to make a head of water), and B C a quantity of iron or wooden pipes extending from 18 to 30, or 40 feet in length, according to their diameter, to conduct the water away: these pipes are laid in a sloping direction, so as to reach the greatest depth D at which the water can run off, which may be from one to six, or eight feet below the head A. The water would naturally run to waste from the end E of these pipes; but that is closed by a blank or solid flaunch, and it is only permitted to escape through a round hole in the centre of the horizontal flaunch F, from whence it will run in an uninterrupted stream. This hole is, however, equipped with a valve within it, as at *f*, and this valve is so adjusted as to sink by its own weight in the water, while that water is motionless or moving slowly. Now if we suppose the pipe B C D to be supplied with water from A, that water will at first pass round the valve, and discharges itself at F; but as soon as it has acquired a small additional force by moving, it will be more than equivalent to the weight of the valve f, and will lift it, by which the passage of the water becomes instantly stopped, and an effort will be made to burst the pipe D; this is prevented by the second orifice over the letter D, communicating with the chamber G and air-vessel H, from whence there is an immediate communication by the pipe I I I, with the elevated situations to which the water is to be thrown. As the effect of the blow which the water makes is instantaneous, it becomes necessary to place a second valve *g* between the air vessel and the chamber G, but below the pipe

I I, so that any water which is thrown into H by the effort may be confined there, and acted upon by the condensed air, instead of permitting it to return and equalize itself in the pipes C, D. The blow which the water makes is so sudden and violent, as to produce an expansion in the pipe D, which is as suddenly succeeded by a recontraction and trifling vacuum in D, by the tendency of the water to return up C when stopped; the effect of this is to bring down the valve *f*, by which a free passage is once more opened for the water, which again flows and shuts *f* as before, to produce another blow or pulsation, by which a second quantity of water is thrown up I I. Each repetition of this operation affords a fresh supply of water.

It will be evident that the valve *f*, as well as *v*, will require some adjustment as to weight. This is effected by making these valves of hollow brass balls, having a hole on one side, by which some shot or small pieces of metal can be introduced to adjust the weight. The hole is afterwards stopped by a screw which projects and forms a shank or tail to guide the valve. The screw over *v* is likewise to adjust the height to which that valve should rise, and to prevent its breaking away and getting into the air vessel, which it otherwise might do from the violence of the blow.

It has been found, that after using the water ram for a short time as it was formerly constructed, the air in H became absorbed and entirely disappeared, and by its ceasing to act as an air vessel, the water would not proceed to any great height up I I. This is obviated in the present case by the chamber G placed between the air vessel and the pipe D. From the form of this chamber any air which enters it becomes confined in the recesses K K, and not only equalizes the action on the valve *v*, but makes the whole motion less instantaneous. K K becomes supplied with air in small machines by the falling of the valve *f*, which brings a small quantity of air down with it. In larger ones it will be necessary to apply a small shifting valve, or spring valve opening inwards to some part of the outside of G, when the air as it enters will rise to the top of K K, and as it accumulates will at length

pass through *v* into H and keep it supplied with air. This latter contrivance I believe originated with Mr. Dobson, of Mortimer-street, Cavendish-square, who has paid considerable attention to the improvement of this engine, and proposes erecting them for the public.

In the rams which I have seen, the tubes B, C, D, have been from $1\frac{1}{2}$ inch to 4 inches diameter, and the ascending pipes I I, one inch, or rather less. I have seen the valve *f* make from 50 to 70 pulsations in a minute, and I should think discharging near half a pint of water at each pulsation, at the height of 30 feet with a six feet head. I am, however, told, that a machine has been made which furnishes an hundred hogsheads of water in 24 hours, to the height of 134 feet perpendicular, with a fall of four feet and an half.

I am not aware that the best proportion of parts has yet been ascertained, or the quantity of loss compared with the quantity delivered up I I, which must in a great measure depend upon the heights of the respective heads, and the size and length of B C compared with the perpendicular fall from A to D. I intend entering into an examination of these points, and if you should think the result of my enquiries worth inserting in a future number of your Journal, they shall be very much at your service.

I remain, dear sir,

Your's very truly,

JOHN MILLINGTON.

Upper Mall, Hammersmith.
10*th June,* 1816.

ART. X. *Some Account of the Life and Writings of M.* DE BOUGAINVILLE. *From the French of M. le Chev.* Delambre.

LOUIS ANTHONY BOUGAINVILLE, a senator, Count of the Empire, and Grand Officer of the Legion of Honour, under the reign of the Emperor Napoleon, was born at Paris on the

eleventh of November, 1729. He was the son of a public notary, descended from an ancient family in Picardy.

It is sufficient eulogium on Bougainville to state, that he acquired the reputation of a great navigator, the rank of a General in the Land, and of an Admiral in the Marine Service, became an Associate in the Academy of Sciences, Member of the Institute, and of the Board of Longitude, solely by his own merit, and that these flattering distinctions were conferred on him as the recompense of various and distinguished services to his country.

Whilst at the university he showed an early propensity to the study both of science and classical literature. On leaving college, in compliance with the wishes of his family, he took the usual steps for becoming an advocate, though at the same time, to gratify his own natural bent, he enrolled himself in the *Mousquetaires*..

Living in the neighbourhood of Clairaut and d'Alembert, he formed an acquaintance with these celebrated geometricians, whom he had frequent opportunities of visiting, and consequently profited much both by their conversation and works. At the age of twenty-five he published his work on the *Integral Calculus,* intended as a supplement to the work of l'Hopital, on infinitely small quantities. That candour, which through life formed one of the principal features of his character, induced him to state in his preface that this work contained nothing of his own, beyond the arrangement and explanations; but the Committee of the Academy, in their report, observed, " that by the perspicuity and acuteness with which he developed the different methods of geometricians, he had in fact made them his own ;" besides this flattering testimony, he was farther recompensed by the consciousness of being useful to students, who were till then completely without guides to enable them to penetrate into a part of the science of mathematics, which at that period had received little explanation.

It might be supposed, that on being nominated Adjutant to a regiment in Picardy, and afterwards Aide-de-Camp to Chevert, he would have forsaken the sciences; but a journey

to London, as Secretary of Embassy, again brought him in union with them: and it was at that period that he was elected a Member of the Royal Society.

In the year following he rejoined his General, and in 1756 went out with Moncalm to Canada, with the rank of Captain of Dragoons; and the best proof of his not having deserted his former pursuits was, that previously to his departure he made arrangements for printing the second part of his book on the *Integral Calculus.*

Immediately on his arrival in America, by an enterprising march through woods nearly impenetrable, and in the midst of snow and ice, he advanced as far as Lake Sacramente, and attacked and burnt an English flotilla under the very guns of the fort which protected it.

In 1758 a detachment of 5,000 French being pursued by an army of 24,000 English, he inspired his companions with the resolution of awaiting the approach of the enemy, and having hastily fortified themselves, in twenty-four hours the English were completely repulsed, and compelled to retreat with great loss. Bougainville, whose advice had so materially conduced to the success of the day, at its close received a slight wound in the head from a spent ball; but notwithstanding this temporary success, little hope was entertained by the governor of saving the colony without speedy reinforcements, he therefore dispatched Bougainville to France to solicit them; he returned with the rank of Colonel and the Cross of St. Louis, this order having been bestowed on him before the usual period on account of his brilliant services.

Being entrusted by Moncalm with the command of the grenadiers and volunteers employed to cover the army which was compelled to fall back on Quebec, he acquitted himself with his accustomed intrepidity and success. But the death of the General soon after having led to the loss of the colony, he returned home, and then accompanied M. Choiseul to Germany, where he continued to distinguish himself, and his valour was rewarded by a present of two pieces of cannon which had been taken in battle.

Though the conclusion of the war deprived him of further

opportunities of shewing his gallantry, his activity remained undiminished.

We have already seen Bougainville as a geometrician and a warrior, and he next appears as the founder of a colony.

His different voyages to America having led to connection with the merchants and owners of privateers at St. Malo's, and a ship belonging to that port having, in the early part of the eighteenth century, anchored on the south-eastern coast of the group of islands called by Hawkins Maiden land, and since, the Falkland Isles, their favourable situation gave rise to the notion of forming an establishment on them, and in 1763 the court of France having turned their attention to this subject, Bougainville offered to make a beginning at his own expense, and having, in concert with two of his relations, fitted out two vessels at St. Malo's, and taken on board some American adventurers, on the 3d of April made these islands, which he called Malouines. They were inhabited by natives, but his taking possession was unaccompanied either by violence or injustice.

An abundance of fish and of fowl, which was caught without any difficulty, insured the new colonists plenty of subsistence, but there was a total want of wood both for building and fuel, though they found plenty of reeds and peat. The lines of a fort were traced out, and the fortifications made with earth. All the colonists following the example of the chief, took a part in the works; in the centre of the fort an obelisk was erected on which was inscribed "*tibi serviat ultima Thule,*" with a portrait of the French king, and on the other side "*Conamur tenues grandia.*"

On the completion of these first operations Bougainville returned to France, leaving the government of his infant colony to his relation. In the year following he again visited them, taking out with him stores and more inhabitants; in an excursion to the straights of Magellan he procured some timber for building, and 10,000 young trees, a most important acquisition to the rising establishment; an alliance was already concluded with the Patagonians; most of the different species of European grain were found

to thrive, and the attempts at cultivation proved successful; the multiplication of cattle was insured, and the number of inhabitants increased from 80 to 150. But these improvements not keeping pace with the activity of the founder, he returned again to Paris, where he learnt, to his mortification, that his success had awakened the jealousy of Spain, who had made remonstrances to the French government respecting the colony, and, after some discussion, Bougainville was himself commissioned with the painful office of giving up his island to the Spaniards, the court of Spain having consented to re-imburse all his expenses, and to pay him the value of the works he made over to them. As some consolation for his disappointment he was permitted by his government to make a voyage round the world, and had the command of La Boudeuse, and the tender L'Etoile was to join him. Commerçon the naturalist, and Veron the astronomer accompanied this expedition, the latter for the purpose of trying new modes of ascertaining the longitude.

It was on the 3d of May, 1766, that Bougainville resigned to the Spaniards his colony, which had existed but for two years, and whose speedy decline he now foreboded. He continued to regret throughout life an observatory he intended to have erected, the position of which being 51° southern latitude, would have rendered it a useful auxiliary to the great observatories of Europe; as a proof of this it may be remarked, that as he was preparing to depart, he observed for several days a comet which was invisible to all Europe; this was the second comet which appeared in the year 1766.

His projects thus completely thwarted, the colony cannot be supposed to have continued much to interest him; all his thoughts were now occupied in preparations for the brilliant expedition he was about to undertake. But he early experienced a disappointment in not being joined by the tender which was to have brought him provisions: conceiving that some accident had been the cause of its not joining him at the Falkland Islands, he thought it best to go in search of it at Monte Video; thus undertaking a voyage of more than 800 leagues; but independant of this proceeding being more

consonant with his restless and eager activity, it afforded him an opportunity of witnessing a scene which at that time engaged the attention of all Christendom: soon after his arrival at Buenos-Ayres the Jesuits of Paraguay were arrested: in his voyage he has with great freedom and candour stated all that can be urged in favour of the government of the missionaries, nor does he seek to disguise their faults, but has abstained from detailing those circumstances pretended to have been discovered in the papers which were seized, the violent prejudices then existing in men's minds rendering it, in his opinion, scarcely possible that he should be enabled to distinguish between that which had foundation and that which was untrue; but he bears testimony in favour of the majority of the fraternity, conceiving them to have been ignorant of the designs of their superiors.

Seven months after his departure he found himself again near the Falkland Islands. The passage of the Straights of Magellan was long and difficult, thick fogs and tempestuous winds compelling them to sound and tack without intermission, and it was here that their discoveries commenced; the names given to newly found islands and bays began to furnish monuments of the labour of the French for the advancement of geography, though the cloudy state of the atmosphere almost wholly prevented Veron from making any astronomical observations.

The hurricanes did not leave them till they had quite passed the Straights; this passage, which Bongainville reckoned at 132 leagues, took up 52 days of most laborious navigation, but the health of the crew was not in the least affected by it; on entering the Pacific ocean there was not one person on the sick list; the navigation now became less toilsome, their discoveries increased, and they were enabled to determine certain points, respecting which the opinion of former navigators were divided. Two islands were also discovered, of which Bougainville took possession in the king's name. Having now been so long at sea, some rest became absolutely necessary to the crew, and he made for Otaheite. No spot could have been found so well calculated to recompense them for

their past dangers and fatigues: but the good reception they met with from the islanders was not unmixed with cares; though on shore they met with every pleasure and luxury, the anchorage was so bad that in nine days they lost six anchors, and this made them as anxious to hasten away from this new Cythera, as they had been eager to approach it.

During their stay at this island a youth named Aotourou determined to accompany them on the voyage; his narratives afforded them much entertainment, and he was frequently useful to them at the other islands where they touched. They found that he knew most of the larger stars, and had names for them, and that he had made several voyages to the neighbouring islands, the positions of which he was enabled to point out, as well as to describe the characters of the inhabitants. He was taken by Bougainville to Paris, where he remained for nearly eleven months; all were eager to see and converse with him; his patron did all in his power to make his stay pleasant, and this kindness was repaid with the most lively gratitude. Nothing was omitted by Bougainville to ensure his return to his native island: he procured him the strongest recommendations, and was at an expense of nearly £1,500. without any certainty of ever being repaid. But neither the attentions of his patron, nor of M. Poivre at the Isle of France, to whom he was recommended, nor of Captain Marcon, who was to take him to his own island, were of any avail: Aotourou died of the small pox during the voyage, as did two other of his countrymen, who had accompanied an English captain who touched at Otaheite about eight months before Bougainville. For some considerable time after quitting this island nothing occurred generally interesting, and the monotony of nautical details is interrupted only by the description of dangers which they had to encounter. Their provisions growing scarce, they were reduced to short allowance, compelled to alter their course, and abandon all attempts to find a passage which was supposed to exist, and which they had been seeking for some time. This glory was reserved for Cook, who discovered it just at a time when his ship was in danger of being lost. Bougainville would have been subject

to similar danger if the want of provisions had not occurred to protect him from it, by compelling him to take another course. They escaped at last from these perils, but the scurvy made its appearance amongst the crew; they were, however, fortunate enough to discover a passage into the *Molucca seas.* Notwithstanding the strict prohibitions which exclude all foreign ships from *Bouron,* the governor granted our navigators permission to repose themselves after their fatigues and perils. Aotourou, transported at the sight of so many new objects, demanded if Paris was finer than Bouron; his enthusiasm soon cooled, however, on observing the baneful effects of the climate of Batavia on the health of the crew, which he called *enoua maté,* "the land which kills." From Batavia they went to the Isle of France, thence to the Cape, and from the Cape to St. Malo, where they arrived on the 16th of March, 1769, after a voyage of two years and four months, during which time they lost only seven men out of a crew consisting of nearly two hundred. This expedition, which was the first voyage round the globe accomplished by the French, ranked Monsieur Bougainville amongst the most eminent navigators. The account of his voyage, which he published, was read with eagerness, and was almost immediately translated by Forster. The style of his work is simple, and well displays the character of the author: his intrepidity, his contempt of danger, which he has almost the appearance of seeking; his kindness and good humour, which enabled him at once to maintain confidence, subordination, and cheerfulness amongs his crew, whose health and comfort engaged his constant attention. It has been said, and with truth, that the charts and the geographical observations, with the exception of the determinations of the latitudes, are the least excellent part of the work; but it should be recollected, that this was a voyage of general discovery, and not undertaken for the mere purpose of making surveys, in which whole months are employed in the laying down an island or a particular shore; and that continued perils and storms rendered abortive nearly all the astronomical observations; that the science relating to the longitudes was then but in its infancy, and that the lunar

tables were not brought to any thing like their present perfection. On his return, France was at peace: a wandering and active life had deprived him of his taste for mathematics, and he devoted himself to those pleasures which in his early years he had not leisure to enjoy. His fame and the elegance his of address rendered his society eagerly sought after by the most distinguished persons.

When France espoused the cause of America, Bougainville was again called into active employ, and he commanded several different ships, under Admirals Lamothe Piquet, d'Estaing, and de Grasse; and, on the application of d'Estaing was made commodore, and the same year he had the rank of Mareschal-de-camp. At the battle of the Chesapeake, in 1781, he commanded the advance, and repulsed the van of the English, and was highly praised by the Count de Grasse, who bore testimony to his having mainly contributed to this victory. On the 12th of April, 1781, a day so disastrous to the French, he had the command of the rear, and by a bold manoeuvre saved the Northumberland; and though his ship was one most disabled, he rallied and conducted to St. Eustacia a part of the shattered fleet.

The peace, which insured liberty to America, restored to him that leisure which revived his love of the sciences, and at this period he was elected a member of the Academy. On his admission he was highly complimented by La Grange on his work on the *Integral Calculus.*

His next scheme was, to make an attempt to reach the north pole; a distinguished astronomer had offered to accompany him, and Bougainville had traced out two different routes; but this project having been rejected by the French minister, the Royal Society requested to be furnished with his observations, and they were submitted to the Society by Bougainville, who noted that which he should prefer. Lord Mulgrave (then Captain Phipps), who had the command of the expedition, chose the other; but he was unable to reach further than the 24th degree.

Ought we, says M. Delambre, to blame or praise the minister for having discountenanced this venturous undertaking?

As we differ, he continues, from Bougainville in an estimation of the merit attached to the overcoming difficulties before considered as insurmountable, and consider the dangers incident to the expedition as one of the greatest objections to it, as far as they are not repaid by the acquisition of some object of utility; and that any utility would result from such a scheme is, we conceive, at the least doubtful. It is not at all probable, that the 90th degree would afford any phenomena which could not be just as well observed at 10 degrees from the pole.

Let it however be supposed all obstacles overcome, and the astronomer arrived at the point so difficult to reach, from whence he beholds the heavens rolling horizontally around him, where the same stars are always perceived and always of the same height, and where the choice of a meridian is arbitrary, where the planets are visible but for half their revolutions, and are for months, nay probably years, concealed by fogs and clouds from the observer; after all, what would be the probable reward of these dangers and fatigues: can it be said that some few loose observations on refraction, and some experiments, in themselves perhaps uncertain, respecting the magnet, would be a sufficient recompense?

If this be admitted, thanks are due to the parsimony or the timidity of the minister for thus preventing one so distinguished as M. Bougainville from exposing himself to such great peril without a fair prospect of any adequate advantage: however, had the expedition been undertaken, it is but just to suppose, that he would have modified his project according to the obstacles he encountered, and that he would have availed himself of any opportunity offered by his situation, and would have added to his reputation, by a display of as much enterprize and courage as is capable of being shewn by man.

A spirit of insubordination having manifested itself in the French fleet at Brest, commanded by M. Albert de Riom, Bougainville, on account of his great reputation and that peculiar firmness mixed with kindness for which he was eminent, was conceived the only person able to persuade the sailors to return to their duty. In this he succeeded, though his success was but of short duration; the minds of the sailors were too far gone, and

their spirit too much excited to permit them to listen patiently to that voice which in other times would have been cheerfully obeyed. At this period he quitted the service, though in 1791 he was included in the list of Vice Admirals; this distinction redoubled his devotion to a Prince whom nearly all had abandoned, and to whom he continued to give proofs, during the times of the greatest danger, of the most courageous attachment. Having miraculously escaped the massacres of 1792 he returned to his estate in Normandy, where he found his two pieces of cannon which had been presented to him, and which were then the sole recompense that remained for forty year's service.

Here he awaited the restoration of tranquillity; during his retreat he was appointed to the board of longitude; but whether he conceived that tranquillity was not sufficiently re-established, or he was prevented by the necessity of taking care of the property he had left, he sent in his resignation and was replaced by the Count Fleurieu, and he himself soon afterwards succeeded M. de Borda; on the foundation of the Institute he was appointed a member in the department of navigation and geography; as a senator and grand officer of the Legion of Honour, he enjoyed in his old age, leisure and dignity; but his ardour was not extinguished; he still retained all the vivacity of his youth, and he eagerly sought the direction of, or share in, some maritime expedition: and when his age was objected to by his friends, his answer was, that Nestor was not useless in an army possessed of Ajax and Diomede. It may be questioned, says M. Delambre, whether the old king of Pylos retained, to such an extent, his powers and his courage, and still more, whether his discourses gave that pleasure to the Greeks, which was experienced by young sailors when listening to Bougainville. He was of an extremely temperate habit, which led to the hope that his existence would have been considerably prolonged; but he died on the 31st of August, 1811, after an illness of ten days, during the whole of which he retained his faculties and accustomed gaiety.

He was an excellent parent, a warm and faithful friend,

and good companion, and unceasingly occupied in forwarding the interests of science and those of scientific men: open and frank, he owed none of his honours to intrigue; and he conducted himself in time of trouble so as to gain the esteem of all parties. He had four sons, one of whom died during his father's life-time. He was succeeded in the Institute by M. de Rossel, the companion and editor of l'Entrecasteaux.

Art. XI. *Review of a Work entitled "An Attempt to establish a pure scientific System of Mineralogy, by the Application of the Electrochemical Theory and the Chemical Proportions. By* J. Jacob Berzelius, *M.D. F.R.S. Professor of Chemistry at Stockholm. Translated from the Swedish Original by* John Black.

Never in the course of our application to a science professedly founded upon strict induction from experiment, has it been our doom to encounter such a chaos of inverted reasoning and gratuitous assumption, such a labyrinth of analogies and generalizations as constitute this "*Attempt at a pure scientific System of Mineralogy.*" Again and again have we toiled through the volume, fearful that in the obscurity of expression, the involution of ideas, and the profundity of calculation, we should have overlooked that accuracy and precision for which the author has been so unequivocally extolled. But notwithstanding our utmost attention, and the assistance derived from the annotations of the learned chemist under whose auspices the work has been introduced to the English reader, we are compelled to pronounce it the most devoted sacrifice of experiment to hypothesis which the modern history of chemistry presents. The theory of Berzelius is the measure of his facts, and like the Grecian robber who extended his victims upon a bed, and if too long cut them shorter, or if too short stretched them longer, this chemical Procrustes screws his results to the preconceived limits of an empirical axiom. Had

this attempt proceeded from a less experienced, or a more unknown hand, we should have left it to merited obscurity; but we owe it to the station we fill to protest against the substitution, by authority, of paper analysis for the labours of the crucible and the furnace.

The doctrine of chemical proportions, as maintained by Dalton, Davy, and Wollaston, we consider as the greatest step to perfection which chemical science has made in these days of her unparallelled progress; but though incontrovertibly founded on fact and experiment, this law is not yet sufficiently developed in detail, to enable us to adopt it as the sole criterion of analytical accuracy: Dr. Berzelius, however, thinks otherwise; and by boldly defining the limits of the theory, by what is termed a *Canon*, is indued by the following short sentence of cabalistic efficacy, with the power, not only of determining in bodies the proportions of ingredients of which the plodding processes of the operative chemist barely denote the existence, but of resolving elements themselves into simpler forms.

"In combinations of two bodies containing each a portion of oxygen, the weight of oxygen in one body is either equal to, or a simple multiple of the weight of oxygen contained in the other."

The truth of this proposition would at first appear to be easily determinable. By the law of definite proportions it is evident, that wherever one of the combining substances is in the state of protoxide, the oxygen of the other must either be its equal, or multiple; but if one of the bodies contain two proportions of oxygen, and the other three, they can form, according to the canon, no binary compound; but two proportions of the latter will unite with one of the former. We maintain, however, that no fair and decisive fact of the latter nature is adduced to establish a generalization of which such extensive use is hereafter made. Let us examine, for instance, the list of salts formed by the union of sulphuric acid with the different bases.

The black oxide of iron has been called a *deutoxide*, because the red oxide contains just half as much more oxygen; and supposing the former a compound of one atom of iron and one

of oxygen, or a *protoxide*, we are forced to admit in the second the absurdity of a half atom. It is therefore proposed to double the simplest numbers by which the proportions of the two are expressed, and calling the black oxide a combination of one atom of iron and two of oxygen, the red oxide will be represented by one and three. But in doubling the number representing iron, it is clear that we must double also the numbers of all the substances with which it combines. Sulphate of iron will therefore be a compound of two proportions (or atoms—we care not which) of sulphuric acid, and one of deutoxide of iron.

Now we shall hereafter have occasion to shew that Berzelius is not entitled to draw any conclusions, on the ground of the inadmissibility of half atoms; but we will nevertheless allow him the full benefit of the argument. It is clear then, says he, that one atom of sulphuric acid will not unite with one atom of the black oxide of iron, because 30, the quantity of oxygen in the former, is not a multiple of 20, the quantity contained in the latter; but two proportions of the acid, containing 60 oxygen, combine with one of the oxide containing 20. But this atomic chemist is here unmindful of what perhaps constitutes the most beautiful and useful part of the theory of definite proportions, namely, the necessity of rendering all the numbers upon a scale equivalent to one another. Let us transfer the sulphuric acid of sulphate of iron, supposing it constituted, as above described, to the oxide of lead. This oxide contains only one proportion of oxygen, and may therefore combine with one of sulphuric acid, and sulphate of lead is so constituted. But as the sulphate of iron contains, according to the above statement, two proportions of sulphuric acid, it requires for its decomposition two proportions of oxide of lead, which, upon the view just quoted, it would not receive; for if we add 207 parts of nitrate of lead (composed of 1 atom of nitric acid $= 67.5 + 1$ atom of oxide of lead $= 139.5$) to 189 parts of sulphate of iron (consisting of 2 atoms of sulphuric acid $= 100 + 1$ atom of deutoxide of iron $= 89$) half the sulphuric acid combines with the

oxide of lead, forming 189.5 sulphate of lead, and 94.5 sulphate of iron remain undecomposed.

The same fallacious reasoning is applied to the oxides of sodium and sulphate of soda. But if sulphate of soda be a compound of two proportions of sulphuric acid and one of deutoxide of sodium, no complete interchange of principles could take place between this salt and nitrate of potash, unless two proportions of the base of the latter were brought into action.

There are no errors in these calculations more to be guarded against than such as arise from doubling or halving, a result for the purpose of making it coincide with preconceived notions of correctness. The mind is apt to be satisfied with the appearance of precision, without viewing the matter in those various relations which a less obvious mean of adjustment would oblige it to pursue. Several of our first chemists have been thus misled. Dr. Thomson not only adopts the fallacies above pointed out with respect to the oxides of iron and sodium, but plunges deeper into error when speaking of sulphate of soda. The composition of this salt he states to be*

$$1 \text{ S. } a. + 2 \text{ So.} = 20.764$$

and thus gives the grounds of his calculations.

" According to Wenzel sulphate of soda is composed of 100 acid and 78,32 base; according to Berzelius of 100 acid and 79.34 base; the mean of which two experiments is 100 + 78.82

No. for sul. acid. No. for soda.

$$\text{Now } 5.0 \;:\; 7.882 \;::\; 100 : 157.64 \text{ and } \frac{157.64}{2} = 78.82."$$

This we hold to be the most perverse error we ever met with.

As one proportion of sulphuric acid is to one proportion of soda, so are 100 sulphuric acid to 157.64 soda, double the quantity which it ought to be, to coincide with the analysis. In this predicament Dr. Thomson halves the result, and thence is led, by we know not what species of induction, to state the proportions of the salt as one of acid and two of soda. Now

* Annals of Philosophy, Vol. II. p. 294.

as one of base compared with one of acid was in double the proportion it ought to have been, so two of acid and one of base would, naturally, have furnished the right result

$$5.0 \times 2 : 7.882 : 100 : 78.82;$$

and hence the inference would be, that sulphate of soda was

$$2.\ S.A + 1 \text{ soda} = 25.7.$$

Dr. Wollaston, in his admirable Paper upon chemical equivalents,* seems to us to afford another instance (we speak with much deference) of the ease of falling into this error. The number for mercury he deduces as 125, upon the following calculations:

	Chlorine.	Mercury.		Chlorine.		Mercury.
Corros. subl.	2 × 67 ;	380	: :	44,1	:	125.4.

The authority referred to for the analysis of the sublimate is Davy, who expressly states,† that the salt contains 380 parts of mercury, and 134 parts of chlorine, the latter being *double* the quantity in the constitution of calomel. The proper statement of the proportions should therefore obviously be

$$2 \times 67 : 380 :: 44{,}1 \times 2 : 250.$$

But the confirmation of the error is drawn in a still more extraordinary way, and proves how cautiously we should submit chemical analysis to the correction of numerical calculation. On various authorities the protoxide of mercury consists of 100 mercury + 4 oxygen; hence

$$4 : 104 :: 10 : 260.$$

The fair inference from which is, that the protoxide of mercury consists of 1 mercury = 250 + 1 oxygen = 10. But Dr. Wollaston having obtained the number 125 for mercury, as before stated, makes the protoxide a sub-oxide, by considering it 2 mercury = 250 + 1 oxygen = 10. But the red oxide contains just double the oxygen of the black oxide, and is correctly represented by $250 + 10 \times 2$; but he halves the numbers, and represents it as a protoxide by $125 + 10$: thus persisting in a number which is equivalent to none other upon the scale, and which he is obliged to double for all its combinations with the other simple bodies.

* Philos. Trans. for 1814, p. 21.

† Elements of Chem. Philos. p. 440.

Sir H. Davy too, by the same error, involves the whole subject in confusion. He sets out, for reasons which appear to us quite insufficient, with considering water as a compound of two proportions of hydrogen and one of oxygen, and calls the former unit, and adopts the number 15 for the latter. He thus introduces in effect two standards of comparison; and from the perplexity arising from two series of numbers, he does not always himself emerge, as the following instance will amply illustrate.

The number denoting chlorine, with reference to hydrogen as the standard, is 33.5, but 67 when compared with oxygen; so likewise the number representing sulphur, compared with the former, is 15, with the latter 30.

" According to my experiments," says he,* " 10 grains of " pure sulphur absorb nearly 30 cubical inches of chlorine; " so that the compound contains about 30 of sulphur to 68.4 " of chlorine; 30 of sulphur to 67 of chlorine would give *one* " proportion of sulphur to *two* of chlorine."

Here it is evident that confusion arises by taking the number for chlorine as compared with hydrogen, which makes 67 chlorine = two proportions, and the number for sulphur as compared with oxygen, which makes 30 = 1 proportion; whereas if they were both compared with one standard, the fair conclusion is, that the compound consists of one proportion or atom of each.

With every allowance for more than one error of this description, Sir H. Davy's modification of numbers refers to an unit, which enters singly into no combination, and a standard of comparison with which nothing is compared.

But we must take another opportunity of entering more at large into the general subject of definite proportions. The digression in which we have indulged can only be justified by the expediency of shewing, from our greatest authorities, the danger of relying too much upon numerical calculations in experimental enquiries. To return to our subject.

Dr. Berzelius is at no loss for *unequivocal demonstrations* of

* Elements of Chem. Philos. p. 280.

his canon; and when he meets with difficulties, most unceremoniously steps over them. He allows that in the list of nitrates there are some which stand as exceptions to the hypothesis; but removes the objection by *supposing* that azote, one of the elements of the nitric acid, and which has hitherto defied the powers of analysis, is itself a compound, containing one atom of oxygen. Thus then the matter stands: the validity of the rule is proved by the oxygen contained in azote, and azote is proved to contain oxygen by the rule.

Let us now enquire what this has to do with a pure scientific system of mineralogy? Nothing, according to our author, is requisite for the right comprehension of the proportions in which the earths and common metallic oxides are combined in a complex mineral, than to ascertain the quantity of oxygen which each contains.

"Every combination of two or more oxides possesses the "nature of a salt, i. e. has its acid; and if we suppose this "combination decomposed by the Galvanic battery, the first "will be collected round the positive pole, and the second "round the negative: hence in every mineral composed of "oxidized bodies, whether of an earthy or saline nature, we "must seek for electro-negative and electro-positive ingre-"dients: and after the nature and qualities of these are "found, a critical application of the chemical theory will tell "us what the fossil in question is."

Ought we now to exclaim with our author, "If with these "theoretical ideas we review the productions of the mineral "kingdom, what a light do they not throw on the compounds "consisting of various metals united with sulphur, or of "various earths and metallic oxides? order becomes at once "visible in this apparent chaos, and mineralogy assumes the "character of a science!"

Let us first proceed a little. It is suggested in a note, that it is of the utmost importance for these calculations to know the quantity of oxygen which each earth contains; and as we perfectly agree in the suggestion, it may not be quite amiss to ascertain the method employed for attaining this desirable end; especially as the mode of proceeding may not immedi-

ately occur to our readers (although very good chemists) any more than it did to ourselves. Let us then hear the Doctor. "The true proportion" (*(of oxygen in silica*) "I have calcu-"lated from John Davy's experiments with silicated fluoric "acid. He found that 100 parts of fluoric acid could be com-"bined with 159 parts silica; and these 259 parts could "farther receive 84.33 parts ammonia. *From the quantity of* "*oxygen in the ammonia the oxygen of the silica may be calculated,* "*because the former must be a multiple of the latter!*"

The quantities of oxygen in two combining oxides must be multiples of one another, because azote contains oxygen: azote contains oxygen, because the quantities of oxygen in two combining oxides must be multiples of one another: silica and ammonia form parts of a combination: ammonia contains azote, and azote contains oxygen; therefore the oxygen in silica must be a multiple of the oxygen in ammonia.

But we must not rest content with introducing our readers to the mere vestibule of this splendid edifice of systematic mineralogy which our author has taken the trouble of constructing; so we momentarily grant the premises, and proceed.

"The ammonia contains 46.88 per cent. of oxygen; conse-"quently the 84.33 parts contain 39.466 oxygen. From my "synthetical experiments on the composition of silica, we "find that 159 parts must contain 76.32 oxygen; but 39.466 "$\times$ 2 = 78.932, which does not materially differ: if then "159 parts silica contain 78.932 parts oxygen, that earth "must contain 49.64 per cent. of oxygen, at which I have in "the subsequent part of this treatise every where com-"puted it."

"The contents of alumina are calculated agreeably to an "essay of mine published long ago at 46.7 per cent. of oxy-"gen; magnesia at 38; lime at 28; barytes at 10.5; soda at "25.66; potash at 17, &c."

All this we must grant, or we shall never come to the main design of the work before us. But the determination of the respective number of atoms or proportions in these oxygenated compounds, presents another stumbling block to our progress. In the essay on the cause of chemical proportions,

upon which these calculations profess to be founded, we find the following solution of the question with respect to silica.*

"The great quantity of oxygen in silica renders it probable "that it contains more than one volume; and as the compo- "sition of the triple fluate of silica and ammonia shews *that it* "*cannot contain three volumes,* it is probable that it contains "two. In that case the volume of silicum ought to weigh "216."

This is a pretty positive assertion; but not a jot less so is the following extract from the present work.

"I have here calculated it (viz. *the contents of the oxygen of the silica,* as it is elegantly expressed) according to the "data formerly laid down by me, on the supposition that it "contains three volumes of oxygen, which *seems to follow from* "*the composition of most siliciates.*"

Now really this is almost intolerable; for although we are aware that it has become customary in elementary books of the science to quote the analyses of Berzelius with the date of the year subjoined, yet he ought to be aware that such unqualified self-contradictions are a positive affront to the good sense of his readers. But, as before shown, we must not be nice in acquiescing in the author's positions, if we ever wish to arrive at the main object of his work, we therefore at once add his list of numbers and calculations of atoms to the preliminary data.

We extract the following

		Number of Vols. of Ox. in the Oxide.
Oxygenium,	10.00	
Silicum,	30.43	
Magnesium,	31.54	
Calcium,	51.02	2
Strontium,	141.81	2
Barytium,	170.91	
Aluminum,	34. 3	

"To enable the reader to determine how far these theore- "tical problems are just or not," the following is the first example offered:

* Annals of Philosophy, Vol. III. p. 252.

A. Example of Single Siliciates.

1. Calcareous Trisiliciate. A stone from Adelfors, the analysis of which by Hisinger affords

	result obtained.	holding Oxygen	atoms.	calculated result.
Silica	57.77	28.75	3	58.42
Lime	35.50	9.80	1	34.58

Now upon this example we have much to say. In the first place, it furnishes an admirable commentary upon the design of making chemical analysis and description the sole basis of mineralogy. If we wanted to add a specimen of calareous trisiliciate to our collection, we are to go to Adelfors. But our journey thither would be the least fatiguing part of the undertaking. The days of Methuselah himself, had he been ever so good an analyst, might have been passed in examining the stones of Adelfors, without discovering the exact species which is composed of silica 57 and lime 35. Still more improbable would it be, amounting almost to impossible, that we should ever identify specimens of the same thing coming from different parts of the world.

Again, with respect to nomenclature. The mineral is a species of the genus "trisiliciates", of the order of "single siliciates." This is, to say the least of it, very bad taste, and looks very like nonsense. Surely some less ambiguous method might have been devised, of expressing the meaning which it is meant to convey. Further, the theory itself is threatened by this the first evidence of its validity: a trisiliciate of lime! How is this possible? Silex contains 3 atoms of oxygen, and lime 2 atoms. Now 3×3 gives no multiple of 2. If, therefore, the oxygen of two combining bodies must be multiples of each other, a trisiliciate cannot exist. But it appears that the silex is made to contain three times as much oxygen as the lime; this would render it a *tri* any thing rather than a trisiliciate. Upon the Doctor's own data it must be a bisiliciate, in which the two earths are united in the only proportion in which they can effect an union.

But then the very next example professes to be calcareous bisiliciate.

" Calcareous Bisiliciate. *Werner's* Schaalstein, Haüy's Spath en tables; Table spar."

Silica, 50	contain Oxygen.	= 24.82——2——50.00	
Lime, 45		= 12. 6——1——44.33	
Water, 5		= 4. 4——½—— 4. 7	

" The silica is here combined with 1½ as much lime as in " the foregoing mineral, and contains, therefore, twice the " oxygen of the base, while the water of crystallization con- " tains ⅓ of the oxygen of the base."

Upon the scale of numbers which we have admitted this is a combination of two particles of silica, containing oxygen = 6, and 1½ particles of lime, oxygen = 3. If such a combination is at all allowable, how little is it characterised by the name assigned to it.

Indeed to our author it seems a matter of perfectly secondary importance whether or not the actual products of the analysis of a mineral are in definite proportions, provided the oxygen which they are supposed to contain can be forced within the limits of his general rule. Thus calamine is a siliciate of zinc.

Silica,	25.0	contain Oxygen	= 12.41——1——26.79
Oxide of Zinc,	68.3		= 13.40——1——66.51
Water,	6.7		

Now the numbers representing silex and oxide of zinc in the table are respectively 60.43 and 100.64, in which proportions, or in the multiple or even submultiple of either, the oxides are not combined, do not by the liberal allowance for error in the calculated result of upwards of 7 per cent. in the silex, and 2½ per cent in the zinc.

But it is among the oxides of iron and their combinations that we shall be most struck with " the fresh life and new " properties which mineral analysis is likely to derive from the publication of this essay."

Many of these oxides have been long known as very refractory; but it appears that they prove not more so to the founder's furnace than to our author's hypothesis.

Some of the Swedish iron ores, it seems, the *magnetic* in particular, afford, as the result of their analysis, an oxide containing nearly a quantity of oxygen intermediate between that of the black and red oxides. The existence of such an oxide is countenanced also by the experiments of Gay-Lussac.

"That such a degree of oxidation cannot exist," says Berzelius, "we already know from the doctrine of chemical "proportions." But, nevertheless, he confirms the fact by his own experiments. Facts are stubborn things, and here is a fine opening for some *new property of mineral analysis*. This oxide is not a *mere* compound of metal and oxygen, although it contains nothing but metal and oxygen. It is a compound of the two known oxides of iron, in definite proportions. It is an *oxidum ferroso-ferricum !*

"The most simple proportion, in which these two oxides "can be supposed combined, is that where the peroxide "contains thrice the oxygen and twice the iron of the pro-"toxide. In such a combination the composition is

Iron,	-	71.8—100
Oxygen,		28.2—39.29

"which therefore coincides as nearly with the proportion "found as we can expect in any experiment. The iron ore "itself thus consists of almost precisely 69 parts red oxide, "and 31 parts protoxide."

But this *new property of mineral analysis* is much too useful to be entirely confined to an oxide of iron : it furnishes effectual means of finding the unity or fundamental particle in any mineral which is stubborn enough to resist the Doctor's canon.

"We must not suppose that these two oxides always appear "in the mineral kingdom combined in the same prportion, "especially as they are to be met with in the form of salts "like arseniates, phosphates, siliciates, &c. because we possess "examples that they can exist in salts in various proportions ; "for example, in prussias ferroso-ferricus (Prussian blue !) "and in subprussias ferroso-ferricus, in which the proportion "of peroxide of iron to the protoxide is not the same. We "must, therefore, never assume oxidum ferroso-ferricum as a "determined basis, but must always endeavour to determine "the quantity of the protoxide, especially as it may occasion-"ally happen that the latter constitutes the unity or funda-"mental particle of the mineral, which we in vain seek for "among the other ingredients."

But why confine so convenient a property of analysis to any one substance?

"In the course of my experiments respecting chemical "proportions, I imagined I found that a great number of "oxides of the same radical, which are to each other in the "proportion of oxygen that they contain $=1:1\frac{1}{2}$ possess the "property of combining, while I know no examples of any "combinations between oxides in which the oxygen is $=1:2$. "Thus, for example, the nitric acid enters into combination "with nitrous acid, peroxide of cobalt with the oxide of "cobalt, peroxide of uranium with the protoxide of uranium, "&c. According to all appearances, the red oxide of manga- "nese, which gives an amethyst colour to many minerals, is "a similar combination of peroxide and protoxide, an oxidum "manganoso-manganicum."

A few more such definite proportions, and the whole theory becomes as indefinite as any advocate of the contrary opinion could possibly imagine or wish!

Having thus attempted to give our readers an insight into the method of ascertaining the composition of some minerals by the oxygen which they contain, perhaps they would wish to be initiated into the mystery of finding the proportions of the ingredients of others by the oxygen which they do not contain. Nothing can be easier. Let us take, as an example, that well-known species, bisulphuretum ferri, with sulphuretum cupri and stibietum plumbi.

	Result of analysis.					Calculated result.
Lead	34.50	Take oxygen in proportional degrees of oxidation.	=2.65.1			29.0
Antimony	16.00		2.03.1			18.0
Copper	16.25		4.06.2	takes sulphur.	4.07	18.0
Iron	13.75		4.10.2		6.25	13.5
Sulphur	13.50				——	15.5
Silver	2.25					
Loss	3.75					

Let it not be supposed from this statement that the mineral contains oxygen. Not a particle. But if it did contain it, these are the proportions in which it would be divided between the metals. What can be clearer than that this mineral is a compound of a particle of stibiet of lead, united with two par-

ticles of sulphuret of copper and two particles of bi-sulphuret of iron? especially when we observe that the computed results agree with the analysis within 12 per cent. of the antimony, 11 per cent. of the copper, and 15 per cent. of the sulphur in deficiency, and 14 per cent. of the lead in excess?

We cannot here forbear mentioning that our author highly disapproves "of the wanton desire shewn by many minera-"logists to metamorphose the names of well known minerals, "by which the study of them is rendered considerably more "difficult, and the synonymy comes to be the most difficult "part of the whole science;" and he asks, "what has miner-"alogy gained by the exchange, when it received Apophyllite "for Icthyopthalmite?" or what, we are disposed to add, by Trisilicias Kalico calcius for both? or what, by any of the cacophonous names of Dr. Berzelius for those already in use?

Our author, it should seem, is nevertheless sometimes seized with a horror of exceeding the bounds of possibility: but then he strains at a gnat, and (what our readers will by this time more readily believe) swallows a camel.

"The difficulties to which the corpuscular theory is subject "arise principally from the circumstance, that there are bodies "in which all the circumstances at present seem to demon-"strate the existence of a half particle, of which, however, "we cannot admit the supposition."

This difficulty he is quite right in endeavouring to annihilate, as his canon introduces more instances of it than would probably have arisen from any other source. The whole secret consists in substituting the word volume for the word atom.

"I call the representation of bodies in a gaseous form the "theory of volumes. It does not admit of all these specula-"tions; and, if I may be allowed to say so, cuts off all farther "investigation of that nature, and confines itself within the "phenomena, which may be proved by experience: I con-"sider it as a leading-string to keep us in the way of truth, "while we are endeavouring in our investigations to pene-"trate deeper into the secrets of the corpuscular theory."

"Gaseous wolframium" a phenomenon which may be proved by experiment! Volatile manganese, a leading-string to keep us in the way of truth! and this to cut off speculation!

In sober seriousness, we believe that Dr. Berzelius does not understand himself. He confounds two distinct terms, and two distinct facts. An atom is not a volume. The combination of two volumes is not the combination of two atoms.

With respect to the meaning of the words, a volume necessarily implies a number of particles in a state of mutual repulsion; an atom as necessarily implies a single indivisible solid. It is therefore not "clear that what in the one theory "is called an atom, is in the other theory a volume."

Again, with respect to the facts, it is not the same thing that a volume unites with a volume, or an atom with an atom: as, for example, two volumes of hydrogen unite with one volume of oxygen; and one volume of hydrogen unites with one of chlorine. But one atom of hydrogen combines with one of oxygen upon one hypothesis, and two atoms of hydrogen with one of chlorine upon the other. Either supposition is irreconcilable with the identity of volumes and atoms.

Before we conclude, we have a word for the Patron of this "*Attempt to establish a pure scientific System of Mineralogy.*" He informs us, that he considers it highly deserving the attention of mineralogists, and likely, if properly followed up, to occasion a most important improvement in the method of analysing minerals, and in the scientific arrangement of them. He thought, therefore, that it would be conferring a considerable favour on the cultivators of that popular science, if an English translation of Professor Berzelius's Essay were laid before the public. His friend Mr. Black kindly undertook the task, stipulating only, that he should compare his manuscript with the original, and take care that it every where conveyed its sense. "This task," says he, "I per- "formed with all the requisite attention, and can, I think, "answer with some confidence for the fidelity of the transla- "tion. The nature of the subject precluded all attempts at

" elegance of language; but I trust that the translation is " every where *perspicuous*."

Now we are not disposed to be captious upon the score of language, or would ask the learned commentator the meaning of " a calculation of the contents of the oxygen of " silica," or, *cui bono*, introduce the trueism, " that a certain " fact is an incontestible proof, for all who can perceive, what " is proved by the existence of it;" but really, when our progress is interrupted, and our minds perplexed by such a sentence as the following, we must withhold our assent to the self-bestowed praise even of perspicuity.

" This difficulty is less perceptible in unorganic nature, " because every composite body is there constituted in such a " manner, that one of its ingredients enters only as an ingre- " dient in one particle, and forms the unity or fundamental " particle, which, in the case of great parts, is effected by " the most electro-positive ingredients round which we can " represent the others analysed in an order that altoge- " ther depends on the electrical poles of the fundamental " particle."

One quotation more and we have done. It is our author's own sentence upon mineralogical innovators:

" Perhaps this strong desire of metamorphosis is no other " than the desire of authors to give something of their own " to science: but such a present, should it go no farther, " it is equally in the power of all to make; and it seldom " excites in the reader that gratitude on which the author " perhaps calculated."

ART. XII. *Review of a Work entitled "Mineralogical Nomenclature alphabetically arranged, with synoptic Tables of the chemical Analyses of Minerals. By* THOMAS ALLAN." *Edinburgh,* 1814.

IN the name of all those who are engaged in the pursuits of mineralogy we thank Mr. Allan for this well-digested and well-executed work. The Babel confusion of the nomenclature of this science has hitherto been no mean obstacle to its more general study, and he who has worked his way through the perplexing jumble of Greek, Latin, German, French, and English, in all their degrees of uncouth admixture, is entitled to no common praise for perseverance and assiduity. For want of some definite and fixed system, the synonymes of this branch of natural history have multiplied with all the waverings of caprice, and a kind of infatuated desire appears hitherto to have prevailed of introducing new names upon every occasion. "Nor would this rage be so mischievous were it confined to one or two philosophers, but unfortunately, like other fashions of a more frivolous nature, it does not fail to obtain imitators." We must own, however, that in the present state of our ignorance with respect to the nature of the union of earthy bodies, we feel strongly averse from any attempts to systematize nomenclature founded upon hypothetical ideas of their constitution; even in the more advanced branches of chemistry we have strongly felt the *inconvenience* of this proceeding, and to this day we are haunted by the ghost of a departed theory in the muriates and hyper-oximuriates, which the force of habit still retains in the vocabulary of the salts.

Mr. Allan has adopted a systematic arrangement nearly similar to that of Haüy, and the first part of his work consists of a tabular disposition of all the known minerals into classes, genera, and species. This is followed by a list of all the synonymes of mineralogical nomenclature to be found both in the older and newer works upon the subject, arranged in alphabetical order. Some local terms and old names which are almost obsolete are likewise inserted; by the former, this work may be rendered useful to individuals who know, nothing

of mineralogy; and by the latter, the progress and improvement of the science will be remarked. The names employed in the synoptic arrangement are all numbered in progression, and are immediately followed by their synonymes; and if the name be that of a mineral which presents different varieties, it is followed in succession by these varieties with all their synonymes, preceded by distinctive letters. The names which are not employed in the system have no numbers prefixed, but are referred to their proper denominations by numbers subjoined. The various species are also referred by numbers to the tables which conclude the work in which are contained their different analyses. These tables are divided into sixteen columns. The first contains the number by which the analysis of any substance mentioned in the list of synonymes may be found: the second presents the systematic arrangement of minerals; the third, the trivial names by which they are most commonly known; the fourth is destined for the locality of the substance analysed; the fifth is intended to represent the specific gravity; the next column contains the name of the analyst, and the ten following the different chemical ingredients of the mineral. To all these various particulars are subjoined most ample references to authorities.

Only one thing more, in our opinion, is wanting, to render this little volume complete, and this we may yet hope to see supplied in some future edition. The mathematical forms of crystallization, wherever they can be ascertained, mark the species with a character of precision which might always be advantageously attended to. The principal modifications of crystals, we think, might have been added to the other characters of minerals with facility, and the addition is the only thing which we can imagine that could have added to the utility and perfection of the plan.

The modest and unassuming pretensions of the author add an additional value to his labours, and we should be unwilling to believe that we could be insensible to the following appeal, even upon occasions which would call for less of acknowledgment and approbation.

"In the system I have thus presumed to publish I hope no

very material errors will be detected; and if there should, I beg it may be considered that although our opportunities for study have in this quarter been of late years highly improved under the auspices of our present Professor of Natural History, Mineralogy has but very recently attracted any considerable attention in this quarter. Our means are therefore still very limited, when compared with other capitals; and it must also be remembered that this is not the work of a professional man, but the result of considerable assiduity, bestowed when avocations of a very different nature would permit; and I trust not unprofitably so to some of those into whose hands this volume may happen to fall. I therefore hope it will not be considered as soliciting more than I deserve, when I beg that inaccuracies may not be too scrupulously criticized."

ART. XIII. *Account of an Ancient Canoe found in Lincolnshire. Transmitted to the Editor by the Right Hon. Sir* JOSEPH BANKS, *Bart. &c.*

THE above wood cut represents an ancient canoe, which was found, in April last, at a depth of eight feet under the surface, in cutting a drain parallel with the river Witham, about two miles east of Lincoln, between that city and Horsley Deeps. It seems hollowed out of an oak tree, and is thirty feet eight inches long, and measures three feet in the widest part. The thickness of the bottom is between seven and eight inches.

Another similar canoe was discovered two years ago in cutting a drain near Horsley Deep, which was unfortunately

destroyed by the workmen before it was ascertained what it was. Its length was nearly the same as that of the former, but it was four feet and a half wide.

Besides these, three other canoes, resembling the above in construction, have been found in the same county. One, in a pasture, near the river Trent, not far from Gainsborough; and two, in cutting a drain through the fens below Lincoln. One of these is deposited in the British Museum.

All these canoes are remarkable for the free grain of the oak timber, so that the millwrights and carpenters who examined it declared, that in their opinion it was of foreign growth, and the produce of a warmer country. This perhaps shews that the growth of our timber has become less rapid and luxuriant, in consequence of the destruction of forests, which has rendered the country more exposed, and its climate less mild.

Art. XIV. *Miscellaneous Observations on the Volcanic Eruptions at the Islands of Java and Sumbawa, with a particular Account of the Mud Volcano at Grobogar.*

The appellation of volcano is used, in its most general sense, to denote elevations formed by the boiling up of liquified earthy matter, which occasionally protrudes from their summits, or from lateral perforations.

In the mountains to which this name was originally applied, the liquifaction seems to have been produced by a vast and intense body of heat. In another class of mountains or hills which, on account of the eruptions they undergo, are likewise called volcanos, the fluidity is occasioned by water, the ebullition by the extrication of gas. As each of these phenomena occur in Sicily, it has been conjectured there may be some connection between them, but they are by no means contiguous to each other; near the site of the Macalubba neither evident currents of lava, nor traces of an ignivomous

crater have been discovered upon the surface, notwitstanding the limestone of the Val di Noto is very much interlined by submarine lava or trap. The eruptions of the mud volcanos near the Cimmerian Bosphorus are attributed by Pallas to the ignition of coal seams or shale: he supposes they explain the formation of amygdaloidal trap. From its geographical situation we may infer, that at this spot there is a large and continual accumulation of the materials which compose coal; therefore, it is quite as possible the effervescence may be connected with its formation as with its destruction, which many philosophers consider as capable of producing the phenomena of Ætna and Vesuvius. The effects witnessed in this island, from the combustion of coal seams, are intermediate, and much less analogous to the operations of volcanoes than may be produced by the combustible bodies which Sir H. Davy has discovered.

Electricity, which always accompanies volcanic action, probably contributes to it, and occasions the simultaneous commotions at considerable distance of space, which are generally attributed to the ramifications of a subterranean furnace.

Of this a remarkable instance appears to have occurred in the island of Java, according to the accounts which we have extracted from the Calcutta Journal for August, 1815.

Sir. J. Mandelslo says, that in the year 1584 ten thousand Javanese were destroyed by an eruption of the mountain near Panaroukan, probably the same which is here called Goonong Rawoong. Of the explosion at Tomboro, in the island of Sumbawa, a more detailed account from an eye witness has been received by Sir J. Banks: at the intermediate island of Lombhooh a considerable subsidence has since taken place.

In the channels between the Sunda Islands there is a strong current to the northward, and in many parts there are no soundings at the depth of 60 fathoms.

Along the southern coasts of this chain, which in general are rocky and precipitous, the level of the sea is several feet higher than it is behind the islands, where considerable deposits of mud have at all times been forming.

The mud volcanos of Solo occur in one of these alluvial beds: they appertain to the same geographical district as the Goonong Rawoong; therefore, they may be supposed to have some connection with it; but we are inclined to attribute them, as we do those of Taman, to the effervescence to which all similar deposits must be liable, in passing from the state of alluvium to that of consolidated strata. This chemical action may be particularly connected with the formation of beds of salt as well as of coal; the materials which in some instances pass into the state of the latter, may, under other circumstances, become so completely decomposed, as to leave receptacles for brine, from which the water may have been evaporated by the heat developed during the combustion of carbonaceous matter, and this may have taken place at a temperature far below that of ignition, as it does in a common dunghill.

We offer these speculations merely as subjects of general enquiry, for which the present epoch is particularly favourable. At the cessation of any great political conflict, the mental activity it has excited is always eager to embrace some new object, and in point of novelty geology has the advantage over most other branches of science. The rapid advances that have been made in our knowledge of the composition of bodies, and of the properties of their elements, have created a boundless desire of pursuing the investigations to which this knowledge leads. Thus together with millions of eyes and ears, almost as many hundred minds beset the career of observation; but the path of observation is frequently dull and obscure, unless illumined by comparison; and as descriptions are most intelligible to those who have travelled, so is the advantage of travelling greatest to those who possess the most numerous sources of information.

Accounts from the mountains of the Niger, or from the farthest India, are perused not merely because the narratives are interesting in themselves, but because they help us to understand the complications of the Alps and the thunders of Vesuvius.

Extract from the Calcutta Monthly Journal for August, 1815.

" *Fort Marlbro', May* —, 1815.

" A somewhat remarkable circumstance has occurred recently on this coast. A noise, as if of the firing of guns, has been heard, nearly at the same time, at different stations, lying between 2° 30′ and 5° 30′ of south latitude.

" The noise was heard by some individuals in this settlement, on the morning of the 11th April. In the course of that day, some Dupatties (or head men) of villages situated at a considerable distance towards the hills, came down, and reported that they had heard a continual heavy firing since the earliest dawn. It was feared that some feud had broken out into actual hostility, between villages in the interior. People were sent to make enquiries; but all was found tranquil.

" Our chiefs here, immediately decided, that it was only a contest between JIN, (the very Devil) with some of his awkward squad, and the manes of their departed ancestors; who had passed their period of probation in the mountains, and were in progress towards Paradise.

" The same noise was heard at the residency of Saloomah, at the same time. The Bugguess Officer there, imagined that the hill people were coming down, and were engaged with the inhabitants of some of the higher villages. He drew out the forces of the station, and made all ready. As the seeming firing continued, people were sent out to make enquiries and observations. All heard it, but none knew whence it proceeded.

" At the Residency of Manna, the same unaccountable cannonade was heard; and here it was supposed that the murdering tribes of Passummah-Ooloo-Manna were advancing.

" At Padang-Goochee, still further south, the same noise was distinctly heard, the same fears entertained, and precautionary measures taken by putting the troops on the alert.

"At the Residency of Moco-Moco, which lies in about 2° 30′ south latitude, the chiefs in the interior were struck by a similar extraordinary noise. They thought the sound came from some place to the southward and eastward of them; but, as they imagined it possible that Fort Ann was attacked from sea-wards, they armed all their dependants and marched down, in a body, for its better defence. It is a standing engagement, that if the chiefs shall ever be assailed from the interior, the Company is to assist them in resisting the attack; and *vice versa*, if the Company's settlements shall be invaded from the sea, the chiefs are to give all possible aid in repelling the enemy.

"At the Residency of Croee, the same impression was made, at the same time, on the minds of all there, that there was a heavy firing at some distance.

"A native residing at Semanko Bay, writes under date 11th April, that a firing of large guns had been heard there all that day, and the preceding night. He, however, accounts for it more naturally than our friends here. He says, that the Narquedah of a Prow, from Bantam, states, that just before he reached Semanko, he had seen 29 sail of ships; and the communicator of the intelligence concludes, that the firing proceeded from these vessels. They (though there is, probably, some mistake as to number) were, perhaps, the homeward-bound China fleet; but no firing from them could have been heard even at Croee: much less at Padang-Goochee, Manna, Soloomah, Marlborough, and Moco-Moco.

"The most natural method of solving the difficulty, is, possibly, by supposing, that there must have been a violent eruption, from some one of the numerous volcanos amidst our stupendous mountains, centrally situate between Moco-Moco and Semanko. If so, we shall not, perhaps, ever learn the particulars; for we have very little communication with, and still less knowledge of, the mountaineers (though some of them are said to be Lord Monboddo's men, and have *tails*) or of the country they inhabit."

"We are at length enabled to give to the public a full and interesting account of the volcanic eruption that has recently taken place on the island of Sumbawa, which has been furnished to us from the most respectable authority, and which may be received as an historical fact of undoubted authenticity.

"The distance of Batavia from the Tomboro mountain is between seven and eight hundred miles, which appears so enormous a space for sound to be conveyed over, that we cannot help supposing the volcano on Sumbawa is in some degree connected with other volcanic mountains on this island. To prove this fact, we now publish an extract from a private letter with which we were obligingly favoured, before any eruption was known to have taken place on the island of Sumbawa, by which it will appear that the dates of the first explosions from the Tomboro mountain, and that behind the Bangewangee, correspond exactly.

Besukie, April 16.

"The mountain that has been kicking up this dust is not in Lumojan, as was generally supposed, but one in the rear of Bangewangee, and in the district of Bondowoso, about 35 paals distant from this place, called Goonong Rawoong; it has been volcanic from time immemorial, sometimes smoking, and once or twice has emitted flames; seven months ago four hillocks that were near the edge of the Crater fell in and choked up the vent. Its first re-opening was about the 4th instant, at which time we had a slight shower of ashes; however, on the 10th, it broke out with louder explosions than were ever before witnessed; we were enveloped in darkness from 4 o'clock P.M. of the 11th—until 2 P.M. of the 12th. The ground here is covered with ashes 2 inches deep, the same at Probolingo, and at Panaroukan; and through the Bangewangee districts, from 8 to 10 inches. The sea was much agitated at the time of these explosions, and on a sudden rose from 5 to 7 feet on the night of the 10th."

"If it be admitted that any relative connection exists between these two volcanos, we may reasonably suppose that their influence extended still further to the westward: and that

other mountains, more immediately in our neighbourhood, have emitted the sounds that were so distinctly heard on the 11th instant at Batavia, and about the same period at Banca;—we may probably be wrong in our conjectures upon this subject; but it certainly appears to us, that any sound which could be conveyed over a space of six or seven hundred miles, must have been insupportable at the distance of 35 paals from the Crater.

"We shall leave the elucidation, however, of this interesting phenomenon to abler pens than ours. The account we have published is so explicit and satisfactory, that hardly any additional knowledge can be obtained, except by personal investigation; and as the convulsions of the Tomboro mountain have nearly rivalled the workings either of Ætna or Vesuvius, we trust some curious traveller may be induced to explore its ravages, and throw further light upon a subject of so much historical interest to our Eastern world."

Extract of a Private Letter.

"On the 5th of April a firing of cannon was heard at Macassar:—the sound appeared to come from the southward, and continued at intervals all the afternoon. Towards sunset the reports seemed to approach much nearer, and sounded like heavy guns occasionally, with slighter reports between.

"During the night of the 11th the firing was again heard, but much louder; and towards morning the reports were in quick succession, and sometimes like three or four guns fired together, and so heavy, that they shook the ship, as they did the houses in the fort. Some of the reports seemed so near that I sent people to the mast-head to look out for the flashes, and immediately the day dawned I weighed and stood to the southward, with a view of ascertaining the cause.

"The morning was extremely dark and lowering, particularly to the southward and S. W. the wind light, and from the eastward. Perceiving a large prow coming from the southward, I sent a boat on board to get any intelligence she might have to give, as she was coming from the quarter from whence

the firing had been heard. The prow was from the island of Salayer: a Dutchman who commanded her stated, that he had heard the firing the whole night, but had seen no vessels or boats; he also stated, that two days previous to his leaving Salayer, about the 4th or 5th, a heavy firing had been heard to the southward of the island; that the guns in the fort had been manned in consequence, conceiving it to be an attack by the pirates on some part of the island; but as no vessels or boats had appeared, it was at length concluded to be an eruption from the volcano on the island of Sumbawa.

"In consequence of this information, and being of the same opinion, I anchored the ship abreast of Macassar, and went on shore to the Resident, with the intelligence. I found that Captain Wood entertained the same opinion, as the house at Macassar had been shook by some of the reports.

"Indeed by this time, which was about 8 A. M., it was very apparent that some extraordinary occurrence had taken place. The face of the heavens to the southward and westward had assumed the most dismal and lowering aspect, and it was much darker than when the sun rose. At first it had the appearance of a very heavy squall or storm approaching, but as it came nearer it assumed a dusky red appearance, and continued to spread very fast over the heavens. By 10 it was so dark that I could scarcely discern the ship from the shore, though not a mile distant. I then returned on board.

"It was now evident that an eruption had taken place from some volcano, and that the air was filled with ashes or volcanic dust, which already began to fall on the decks. By 11 the whole of the heavens was obscured except a small space near the horizon to the eastward; the wind being from that quarter prevented for a short time the approach of the ashes; it appeared like a streak of light at day break, the mountains on Celebes being clearly visible, while every other part of the horizon was enveloped in darkness. The ashes now began to fall in showers, and the appearance altogether was truly awful and alarming. By noon, the light that had remained in the eastern part of the horizon disappeared, and complete darkness had covered the face of day:—our decks were soon covered

with falling matter; the awnings were spread fore and aft to prevent it as much as possible from getting below, but it was so light and subtile, that it pervaded every part of the ship.

"The darkness was so profound through the remainder of the day, that I never saw any thing equal to it in the darkest night; it was impossible to see your hand when held up close to the eye:—the ashes continued to fall without intermission through the night. At 6 the next morning, when the sun ought to have been seen, it still continued as dark as ever; but at half past seven I had the satisfaction to perceive that the darkness evidently decreased, and by 8 I could faintly discern objects on deck. From this time it began to get lighter very fast, and by half past 9 the shore was distinguishable; the ashes falling in considerable quantities, though not so heavily as before. The appearance of the ship, when day light returned, was most extraordinary; the masts, rigging, deck, and every part being covered with the falling matter; it had the appearance of calcined pumice stone, nearly the colour of wood ashes; it lay in heaps of a foot in depth in many parts of the deck, and I am convinced several tons weight were thrown over board; for although a perfect impalpable powder or dust when it fell, it was, when compressed, of considerable weight; a pint measure filled with it weighed 12¾ oz.; it was perfectly tasteless, and did not affect the eyes with any painful sensation; it had a faint burning smell, but nothing like sulphur.

"By noon on the 12th the sun again appeared, but very faintly, through the dusky atmosphere, the air still being charged with the ashes, which continued to fall lightly all that day and the succeeding one.

"On going on shore at Moressa I found the face of the country completely covered to the depth of an inch and a quarter. Great fears were entertained for the crop of paddy that was on the ground, the young plants being completely beaten down and covered by it;—the fish in the ponds at Moressa were killed, and floating on the surface, and many small birds lying dead on the ground. It took several days to clear the ship of the ashes: when mixed with water they

formed a tenacious mud, difficult to be washed off. My chronometer stopped, owing, I imagine, to some particles of dust having penetrated into it.

"From the 12th to the 15th the atmosphere still continued very thick and dusky from the ashes that remained suspended, the rays of the sun scarce able to penetrate through it, with little or no wind the whole time.

"On the morning of the 15th weighed from Macassar with a very light wind, and on the 18th made the island of Sumbawa. On approaching the coast, passed through great quanties of pumice stone floating on the sea, which at first had the appearance of shoals; so much so, that I hove to, and sent a boat to examine one, which at the distance of less than a mile I took for a dry sand bank, upwards of three miles in length, with black rocks upon several parts of it, concluding it to have been thrown up during the eruption. It proved to be a complete mass of pumice floating on the sea, with great numbers of large trunks of trees and logs among it, that appeared to be burnt and shivered as if blasted by lightning. The boat had much difficulty in pulling through it; and until we got into the entrance of Bima Bay, the sea was literally covered with shoals of pumice and floating timber.

"On the 19th arrived in Bima Bay; in coming to anchor grounded on the bank off Bima Town, shoaling suddenly from eight fathoms. As the tide was rising, hove off again without any difficulty or danger. I imagine the anchorage at Bima must have altered considerably, as where we grounded, the Ternate Cruiser, a few months since, lay at anchor in six fathoms. The shores of the bay had a most dreary appearance, being entirely covered with ashes, even up to the summit of the mountains. The perpendicular depth of the ashes, as measured in the vicinity of Bima Town, I found to be three inches and three quarters.

"From the account given me by the Resident of Bima, it appears that the eruption proceeded from the Tomboro mountain, situated about forty miles to the westward of Bima. On the night of the 14th the explosions he represents as most

terrific; and compared them to a heavy mortar fired close to his ear.

"The darkness commenced about seven in the morning, and continued until the middle of the following day, twelve hours longer than it did at Macassar. The fall of ashes was so heavy as to break the roof of the Resident's house in many places, and render it uninhabitable, as well as many other houses in the town.

"The wind was still during the whole time, but the sea uncommonly agitated. The waves rolled in upon the shore, and filled the lower part of the houses a foot deep; every prow and boat was forced from the anchorage, and driven on shore; several large prows are now lying a considerable distance above high water mark.

"At the time of our arrival at Bima, no accounts whatever had been received of the state of the country since the eruption. A messenger had been dispatched by the Resident to Sumbawa three days before, and another was sent off to Tomboro immediately after we landed: as he was expected to be back the third day, I determined to wait his return.

"On the 22d the Dispatch country ship arrived in the bay from Amboyna. This vessel had mistaken a bay called Dampoor Sanjier Bay for Bima, and had gone into it; her boat was on shore at Sanjier, the Raja of which place informed the officer, that the greater part of the town and a number of people had been destroyed by the eruption; that the whole of his country was entirely desolate, and the crops destroyed. The town of Sanjier is situated about four or five leagues to the S. E. of the Tomboro mountain. The officer found great difficulty in landing in the bay, a considerable distance from the shore being completely filled up with pumice stones, ashes, and logs of timber; the houses appeared beaten down and covered with ashes.

"As neither of the messengers had returned on the evening of the 22d, owing, as the Resident supposed, to the country being impassible, I did not think myself at liberty to delay the ship any longer. I left the bay at eleven at night, and the next day was off the Tomboro mountain.

"In passing it at the distance of about six miles, the summit was not visible, being enveloped in clouds of smoke and ashes, the sides smoking in several places, apparently from the lava which has flowed down it not being cooled; several streams have reached the sea; a very considerable one to the N. N. W. of the mountain, the course of which was plainly discernible, both from the black colour of the lava, contrasted with the ashes on each side of it, and the smoke which arose from every part of it. The Tomboro mountain, in a direct line from Macassar, is about 217 nautic miles distant."

Copy of a Paper transmitted from Java by S. T. Goad, *Esq. of the E. I. C. Bengal Civil Service, to* S. Davis, *Esq. and by him to the Editor.*

Having received an extraordinary account of a natural phenomenon in the plains of Grobogan, fifty pals or miles N. E. of Solo, a party, of which I was one, set off from Solo on the 8th of September to examine it.

On approaching the village of Kuhoo, we saw, between two trees in a plain, an appearance like the surf breaking over rocks, with a strong spray falling to leeward. The spot was completely surrounded by huts for the manufacture of salt, and at a distance looked like a large village. Alighting, we went to the Bludugs, as the Javanese call them. They are situated in the village of Kuhoo, and by Europeans are called by that name. We found them to be on an elevated plain of mud, about two miles in circumference, in the centre of which immense bodies of salt mud were thrown up to the height of from ten to fifteen feet, in the forms of large globes, which bursting, emitted volumes of dense white smoke. These large globes or bubbles, of which there were two, continued throwing up and bursting seven or eight times in a minute by the watch. At times they throw up two or three tons of mud. We got to leeward of the smoke, and found it to smell like the washing of a gun barrel. As the globes burst, they threw the mud out from the centre with a pretty

loud noise, occasioned by the falling of the mud upon that which surrounded it, and of which the plain is composed. It was difficult and dangerous to approach the large globes or bubbles, as the ground was all a quagmire, except where the surface of the mud had become hardened by the sun; upon this we approached cautiously to within fifty yards of the largest bubble or mud pudding, as it might very properly be called, for it was of the consistency of a custard pudding, and of very considerable diameter; here and there, where the foot accidentally rested on a spot not sufficiently hardened to bear, it sunk, to the no small distress of the walker.

We also got close to a small globe or bubble (the plain was full of them of different sizes) and observed it closely for some time. It appeared to heave and swell, and when the internal air had raised it to some heighth, it burst, and the mud fell down in concentric circles, in which shape it remained quiet until a sufficient quantity of air was again formed internally to raise and burst another bubble. This continued at intervals from about one-half to two minutes. From various other parts of the quagmire, round the large globes or bubbles, there were occasionally small quantities of mud shot up like rockets to the height of 20 or 30 feet, and accompanied by smoke. This was in parts where the mud was of too stiff a consistency to rise in globes or bubbles. The mud at all the places we came near was cold on the surface, but we were told it was warm beneath. The water which drains from the mud is collected by the Javanese, and by being exposed in the hollows of split bamboos to the rays of the sun, deposits crystals of salts. The salt thus made is reserved exclusively for the Emperor of Solo. In dry weather it yields 30 dudgins of 100 catties each, every month, but in wet or cloudy weather less.

In the afternoon we rode to a place in a forest called Ramsam, to view a salt lake, a mud hillock, and various boiling or rather bubbling pools. The lake was about half a mile in circumference, of a dirty looking water, boiling up all over in gurgling bodies, but more particularly in the centre, which appeared like a strong spring: the water was quite cold

and tasted bitter, salt, and sour, and had an offensive smell. About 30 yards from the lake stood the mud hillock, which was about 15 feet high from the level of the earth. The diameter of its base was about 25 yards, and its top about eight feet, and in form an exact cone. The top is open, and the interior keeps constantly working and heaving up mud in globular forms, like the Bludugs. The hillock is entirely formed of mud which has flowed out of the top; every rise of the mud was accompanied by a rumbling noise from the bottom of the hillock, which was distinctly heard for some seconds before the bubbles burst. The outside of the hillock was quite firm. We stood on the edge of the opening and sounded it, and found it to be 11 fathoms deep. The mud was more liquid than at the Bludugs, and no smoke was emitted from the lake, hillock, or pools.

Close to the foot of the hillock was a small pool of the same water as the lake, which appeared exactly like a pot of water boiling violently; it was shallow, except in the centre, into which we thrust a stick 12 feet long, but found no bottom. The hole not being perpendicular, we could not sound it with a line.

About 200 yards from the lake were several large pools or springs, two of which were 8 and 10 feet in diameter. They were like the small pool, but boiled more violently, and smelt excessively. The ground around them was hot to the feet, and the air which issued from them quite hot, so that it was most probably inflammable; but we did not ascertain this. We heard the boiling 30 yards before we came to the pools, resembling in noise a water-fall. The pools did not overflow; of course the bubbling was occasioned by the rising of air alone. The water of one of the pools appeared to contain a mixture of earth and lime, and from the taste to be combined with alkali. The water of the Bludugs and the lake is used medicinally by the Javanese, and cattle drinking of the water are poisoned.

Art. XV. *The Marquis of* Ridolfi's *Method of separating Platina from the other metallic Substances which are found with it in the State of Ore; from the "Giornale di Scienze ed Arti," published at Florence.*

The Marquis Ridolfi after giving a detail of various experiments which he has made upon platina, proceeds thus: "No one has been able to combine sulphur with platina, so as to form a sulphuret of that metal. From this peculiarity of platina, the idea struck me that if one could convert the other metallic substances found in platina into sulphurets, it would be easy to purify that metal. With this view, I took an ounce of crude platina, and separated from it some of the extraneous substances usually mixed with it. I washed it with nitro-muriatic acid, diluted with four times its weight of water. I then washed it in hot water, with a view of removing portions of iron and of gold which might be in the powder; but I afterwards found these washings useless. I then melted the mass with half its weight of pure lead, and threw it into cold water, and thus obtained an alloy which was pulverised and mixed with an equal portion of sulphur. I threw the mixture into a white hot Hessian crucible, which was instantly covered, and let it remain in an intense heat for ten minutes. I then suffered it to cool gradually. It contained much dross, and a brittle metallic button composed of platina, lead, and sulphur. I then again fused it with a small addition of lead, and when it had cooled I found that the sulphur was in the dross, and that there only remained an alloy of platina and lead.

I then heated this alloy to whiteness, and beat it with a hot hammer on a hot anvil, which forced out the lead in fusion. Here I must observe that unless the alloy is white hot the beating must be suspended, as it will break.

I thus obtained platina so pure as to make with it a capsule, a spoon, wire, and leaves which were nearly as thin as gold leaf. It was ductile, malleable, and as tenacious as that obtained from the ammoniacal muriate. Its specific gravity was 22,630.

This description is sufficient to shew the purity of the platina. I repeated the process several times. I did not always find the platina in a lump at the bottom of the crucible, it was sometimes scattered in globules amongst the dross. In this case it is only necessary to heat the mass with a little diluted sulphuric acid, the globules are soon liberated from the dross, and sink to the bottom of the crucible. Collect and wash them, and submit them to the same operation of the hammer, as if the platina had been found united in one mass with the lead. I did not ascertain whether all the metals contained in the ore had become sulphurets, but they were all separated from the platina during the fusion and the formation of the sulphuret of lead.

On the native caustic Lime of Tuscany; by the Marquis Ridolfi.

The interesting communication of Dr. Giovacchino Taddei respecting his discovery of caustic lime in the water of the ancient bath of Santa Gonda, in August, 1815, induced me to visit the spot. The following is the result of my researches:

The bath is situated in a laguna in the corner of a field near the high road to Pisa, which divides the plain called la Catena, from the mountains of Cigoli and San. Miniato. The soil is a mixture of clay, calcareous earth, silicious sand, and vegetable matter. There are two sources of water, one issues from the bottom of the laguna, and the other from the side. The first is hot, raising the thermometer of Reaumur to $35\frac{1}{4}$. It is so saturated with lime, that upon cooling the water, it deposits a considerable quantity. It contains also muriate of lime, and muriate of soda. The upper spring contains a little carbonic acid gas, some sulphuretted hydrogen, and some sulphate of soda. The following is the manner in which the caustic lime is formed in this bath. The lower spring yields a quantity of lime, but as this spring does not rise freely, but oozes through the bottom of the bath, the lime forms a stratum at the bottom of the lagune; which stratum absorbing the carbonic acid gas of the water above, passes to the state of a carbonate, and thus forms a defence to the lime, which is

continually depositing itself underneath, and prevents it losing its causticity. In fact, the caustic lime is found inclosed between the stratum of the carbonate of lime and the clayey bottom of the laguna.

Signor Taddei found the masses of caustic lime so large, that he could not get them out but by breaking them into pieces. He, however, succeeded in removing the whole of it: and I, having visited the spot two months after, found small incrustations of the same substance newly formed.

Analysis of the native caustic Lime. By Mr. Faraday, *Assistant in the Laboratory of the Royal Institution.*

This substance came to England in a bottle filled up with water, the atmospherical air being perfectly excluded.

It is almost entirely soluble in muriatic acid without effervescence, leaving nothing but a few light flocculi. The solution, when tested, was found to contain lime and iron.

A clean uniform piece of the substance was dried, as much as could be, by bibulous paper. A fragment of it being heated red, lost 62.26 per cent. of water.

The remainder, weighing 188 grains, was dissolved in muriatic acid, and evaporated at a high heat on the sand bath, acid was again added, and the evaporation repeated. Water was poured on it, and the silica separated: when well washed, dried, and heated red, it weighed 7.5 grains.

The filtered solution was precipitated by carbonate of potash, and the precipitate boiled in solution of pure potash. The solution was separated from the solid matter, neutralised by sulphuric acid, and precipitated by carbonate of ammonia. The precipitate, when well washed and dried, weighed 9.5 grains. It was soluble in sulphuric acid, and possessed the properties of alumina.

Diluted sulphuric acid was added to the solid matter, not acted upon by the potash: the whole boiled for some time, and then filtered. The sulphate of lime obtained weighed, after being heated red, 136 grains, which, estimating the lime at 43 per cent., is equivalent to 58.48 grains of lime.

The sulphuric solutionwas precipitated by ammonia, and two grains of oxide of iron were obtained.

Supposing the quantity of water in every part of the piece first taken to be uniform, it would follow that the 188 grains contained 117.05 of water; so that 70.95 was the quantity of dry matter acted upon. The results were

	Grains.
Silica - -	7.5
Alumina -	95
Lime -	58.48
Oxide of iron -	2
	68.93

The loss is therefore rather more than two grains, which may, perhaps, actually have taken place, and the difference may have been derived from the unequal diffusion of water throughout the piece.

Supposing 100 parts of the specimen to have been taken, the analysis will stand thus:

	Grains.
Lime - -	82.424
Silex - -	10.57
Iron - -	2.82
Alumina - -	1.34
Loss - -	2.846
	100.000

It is, perhaps, worthy of observation, that during the solution of the substance in muriatic acid, a part only of the silica separated; the greater part remained in solution until heat was applied, when it gelatinised, as in the case where it is separated by an acid and heat from its combination with alkali.

Observations on the preceding Paper. By Sir H. Davy, *V. P. R. I. F. R. S.*

The Duchess of Montrose was so good as to send me the caustic lime which is the subject of the preceding analysis;

her Grace received it immediately from Tuscany. It was in a bottle, carefully sealed and full of water. Some of the exterior portions had become combined with carbonic acid before they were collected, and from the colour, it appeared that there were different portions of protoxide of iron in different parts of the substance.

On examining the water, it was found to be a saturated solution of lime, and it contained fixed alkali, but in quantities so minute, that after the lime was separated, it could be made evident only by coloured tests.

It appears from Mr. Faraday's analysis, that the menstruum which deposits the solid substance must be a solution of silica in lime-water; and heat is evidently the agent by which the large quantity of lime deposited is made soluble, and is enabled to act on silica; and the fact offers a new point of analogy between the alkalies and the alkaline earths.

Vestiges of extinct volcanoes exist in all the low countries on the western side of the Appenines; and the number of warm springs in the Tuscan, Roman, and Neapolitan states, prove that a source of subterraneous heat is still in activity beneath a great part of the surface in these districts.

Carbonic acid is disengaged in considerable quantities in several of the springs at the foot of the Appenines; and some of the waters that deposit calcareous matter, are saturated solutions of this substance. Calcareous tufas of recent formation are to be found in every part of Italy. The well known Travertine marble, Marmor Tiburtinum, is a production of this kind; and the Lago di Solfaterra near Tivoli, of which I shall give a particular account on a future occasion, annually deposits masses of this stone of several inches in thickness.

It is scarcely possible to avoid the conclusion that the carbonic acid, which by its geological agency has so modified the surface of Italy, is disengaged, in consequence of the action of volcanic fires on the lime-stone, of which the Appenines are principally composed. and liberated at their feet, where the pressure is comparatively small; but the Tuscan laguna offers the only instance in which the action of these fires extends, or has extended, to the surface at which the water

collected in the mountains finds its way to the sea, so as to enable it to dissolve caustic calcareous matter.

Art. XVI. *Abstracts from the Travels of* Ali Bey *and* Robert Adams.

Travels of Ali Bey *in Morocco, &c. Longman, 2 vols. 4to.* 1816.

Although it is not conceived to be within the province of our Journal to give Reviews of Travels, it is presumed that it will be interesting to our readers to have general notices of such as relate to any particular branch of science.

Two quarto volumes have been lately printed in London, purporting to be the Travels of *Ali Bey* in Morocco, Tripoli, Cyprus, Egypt, Arabia, Syria and Turky, between the years 1803 and 1807. In the Advertisement, the publishers, after stating they are not at liberty to mention the personal reasons which have induced the author to write and print his travels *under the name of Ali Bey*, inform us, that he was always known on the Continent under that name, and then proceed to mention such facts as they think necessary, to prevent any suspicion as to the genuineness of the travels, or the author. Among the rest is a letter from Mons. Humboldt to Miss H. M. Williams, in which he notices him " as the celebrated " traveller, who, *under the name of Ali Bey*, had visited Mecca, " and who was then at Paris, superintending a translation of " his journal, *which was very curious.*" Ali Bey resided at Morocco from June 1803 to October 1805, when he embarked at Larisch for Tripoly; in January 1806, he sailed for Cyprus, and arrived at Alexandria in May; in October he went to Cairo, in December to Suez, and thence sailed to Jeddo; he proceeded on the Mahomedan pilgrimage to Mecca, where he arrived in January 1807, returned to Cairo in June of that year, and went with the caravan to Jerusalem in July; from thence to Acre, Mount Carmel, Nazerath, the Sea of Gallilee,

the River Jordan, Damascus and Aleppo; and at the end of October visited Constantinople.

We are unacquainted with the motives which induced this traveller to assume the name of Ali Bey. He was well known in this country some years ago, and was in London in the year 1814: his real name is Badia, and he is by birth a Spaniard: he travelled as a Mahometan prince, and was every where received as such; his description of the Musselman manners and customs have peculiar interest. We think the account of his stay in Morocco, and of Mecca, its temple, and the Holy Mount, and the ceremonies performed by the pilgrims, the most amusing part of the work. We have been, however, chiefly led to notice it, from its containing some additional information and reasoning respecting the disputed points of African geography which have so long engaged the scientific world.

One of the most important questions yet remaining to be solved with regard to the continent of Africa, is the course of the Niger *beyond* Tombuctoo, and its *terminations.* The Niger, according to the information of Mr. Park and Major Houghton, rises at Sankari, in the high country on the frontier of Manding; thence it is ascertained, by ocular observation, to pursue a course of about 300 miles towards Silla, and then flows 400 miles farther to Houssa. Positive testimony here deserts us, unless at the single point of the ferry in Cassina; but all accounts, both ancient and modern, seem to agree in stating, that there is a continuous river-course from thence to the eastern extremity of Wangara, being 970 geographical miles, which makes an entire course of 1670 miles. (*Rennell's Illustrations of Park,* chap. vi.) In Wangara it forms several lakes; and that country is entirely surrounded and intersected by its branches. It would appear from *Edrisi,* as if there were a communication between these waters and the lake of Kauga, undoubtedly the same described to Mr. Brown under the name of Fittré.

There is thus a continued stream from the source of the Niger in Manding, to the eastern extremity of Wangara. The next question is as to the direction in which it flows.

This is established to be from West to East, by ocular observation, as far as Silla; by highly probable evidence as far as Houssa; and Major Rennell undertakes to prove, that it follows the same course as far as Wangara. He quotes the testimony of a Moorish merchant, who had visited Houssa, and told Mr. Beaufoy, that persons sailed thence to Ghinny (Gana) *with the stream.* The description given by Edrisi of Wangara, and partly also of Gana, is that of a country environed, intersected, and during the rainy season, inundated by the waters of the Niger. These waters, therefore, spread over the extensive surface, and partly formed into lakes, may, he conceives, be entirely evaporated. It is possible, however, that a part may flow still further eastward, and be lost in the lake of Fittré. (*Illustrations of Hornemann,* chap. iii.)

This opinion, at one time generally received, has of late been strongly controverted, and other conjectures, of a very opposite nature, brought forward; one, which seems very prevalent in Africa, is that the Niger flows eastward till it joins the Egyptian Nile, with which it forms one and the same river; another hypothesis, which has also of late attracted great attention, is that so zealously adopted by Mr. Park, that the Niger joins the Congo or Zaire. This opinion, it should be observed, was not derived from any facts observed by Park, but was adopted from a Mr. Maxwell, an African trader, who had examined the Congo, and made a chart of its lower extremity.

It is farther stated by Mr. Maxwell, that it swells considerably, some time after the Niger is in flood, and before any rains have fallen to the south of the equator. Hence, he infers, that its sources lie far to the north; and this, combined with its extraordinary magnitude, and the mystery which involves the termination of the Niger, is conceived to establish a strong probability, that the two rivers are one and the same.

Another hypothesis, nearly similar, is advanced by M. Reichard, an eminent German Geographer, who makes the Niger fall into the sea, through a number of estuaries, not yet explored, in the Gulf of Benin. But this, though a more

plausible notion, is wholly destitute of any positive evidence in its favour; it is equally liable, with the former, to the objections arising from the direction of the great central chain of mountains; and, besides, the supposition that the estuaries in question form branches of one great river, is purely conjectural.

Mr. Hugh Murray, the author of the article *Africa*, in the new Supplement to the Encyclopedia Britannica, advances another hypothesis, viz. that the great river-course which stretches across Africa, consists in fact of *two rivers*, to both of which the name of Niger has been given; that one of these flows *eastward*, by Sego and Tombuctoo, the other *westward*, through Wangara and Cassina; and that these two rivers, at some intermediate point, not far from the modern position of Houssa, unite in a common receptacle.

It is to be observed, that Major Rennell, in support of his opinion, that the Niger flows *eastward, through Cassina to the lakes of Wangara*, urges, as an argument, "if this river of "Cassina flows *westward*, there must be a common receptacle "between that place and Tombuctoo; but '*we have not*,' says he, "*heard of any such*."

The author of the article *Africa* has collected together a considerable body of evidence (by comparing the ancient and modern accounts), tending to shew the existence in this quarter of an immense lake or inland sea sufficient to form such a receptacle.

Amongst the rest, Mr. Jackson expressly states, that 15 days journey to the east of Tombuctoo (that is, three or four beyond Houssa), there is an immense lake called the Baher Soudan, or Sea of Soudan.

Having given our readers these hypotheses respecting the disputed points, we shall proceed to notice such information as is to be collected from the travels of Ali Bey relating to this subject.

His position is, that there exists in the middle of Africa a *Mediterranean* Sea, which, like the Caspian in Asia, does not communicates with the ocean.

There is, in the interior of Africa, a space of 33½ degrees

from east to west, or from the source of the Niger to the source of the Misselad, and of more than 20 degrees from north to south, or from the southern declivity of mount Atlas and the other mountains which border on the Mediterranean, to the northern declivity of the mountains of Kong, and to the sources of Bahar Kulla. From this immense surface not a drop of water flows into the exterior seas of Africa. Yet we know the sources of the rivers which flow into the Mediterranean and the western ocean; and all these sources are beyond the limits of the vast surface we have noticed. The rivers which fall into the gulf of Guinea are not much more abundant than the others, and therefore give no reason to suppose a more distant source from their mouth than the meridional declivity of the mountains of Kong, and others, which following the same easterly line, unite with the mountains of Komri, or of the Moon, where are the sources of the Bahar el Abiud, or the White River, the principal arm of the Nile.

It is known that the rivers of this part of Africa direct themselves in lines convergent towards the centre; the rivers of the Atlas and those of the Desert, to the south and south-east; the Niger, and those which come from the mountains of Kong, to the north-east and east; the Misselad, the Kulla, and many other intermediate ones to the north-west; the Kuku, the Gazel, and others, to the south and south-west; in a word, all those of the interior part of Africa which are known to us, have their direction towards the centre of this continent.

He then proceeds to shew that a sea of an extent like the the Caspian, or Red Sea, in the middle of Africa, would not by evaporation lose half the quantity of water which the rain annually supplies, and that more than one half would be left for other kinds of absorption.

He then contends that it is impossible that the Niger should lose itself in the marshes of Wangara, and explains what becomes of so many rivers, which we see taking a direction towards the centre of Africa, without seeing the final part of their course.

They also prove, says he, the impossibility of this immense

mass of water getting out by way of the Guinea coast, as has been pretended by a learned German. In fact, the Niger and the Senegal have their source in the mountains of Kong, not far from each other, and take their respective directions, the one towards north-east, and the other towards north-west. The former, after a course of about 400 miles, arrives at Gimbala, on the frontiers of Sahhara; and the second, after having taken a turn of about the same distance, waters the bounds of the same desert in the vicinity of Faribe. Here the situation of both rivers becomes quite the same. The Senegal, in order to get from Faribe to the sea, which is only about 120 miles distant, makes a thousand circuits, and forms of its waters numerous lakes and marshes in a flat country, which is almost at a level with the ocean; so that one may positively assert, that if the sea were to withdraw about 250 miles from its present coasts, and keep the same level, the Senegal would not be able to attain it, but must lose itself in one or two lakes.

For much greater reason will the water of the Niger, which at Gimbala is in the same position as the Senegal is at Faribe, not find a sufficient declivity to attain the ocean, as it would have 360 miles to pass, which is treble the distance of the Senegal's course. And here begins the great lake, or the interior sea of Africa, which, extending, in its presumed dimensions, goes to the lake of Fitré, into which fall the rivers Gazel, Misselad, and others. It communicates also with the lake of Semegonda, " which I consider as a bay or gulph of our Caspian sea in Africa."

But if, from the place where I suppose this interior sea to begin, the Niger had still 600 miles to run, and the Gazel, the Misselad, and others, about 800, in order to arrive in a straight line at the Gulf of Guinea, it is manifest, that not finding a declivity in the territory, they would spread and lose themselves in lakes, without arriving at the gulf.

The rivers Formoso and Rey, as well as others which fall into the gulf of Guinea, receive their water from an extensive surface, by which they are raised to the rank of the greatest rivers. Thus from the southern declivity of the mountains

Kong and Komri to the ocean, a surface of 180,000 square miles is more than sufficient for all these rivers, in a country where a territory of less than half the extent produces the great rivers of Senegal, Gambia, Rio Grande, Mezurado, and many others. There are formed near Cape Roxo and the islands of Bissagos, a multitude of large channels and lakes, which may be compared with those formed by the Rio Formoso and the Rio de Rey, on the gulf of Guinea. The general map of the north of Africa, which is here subjoined, represents the particulars of this system; and as it has been copied from that published by Major Rennell, it also shews without deranging any point in the known geography, that the existence of the supposed interior sea gives a solution of the problem concerning the issue of the interior rivers of Africa.

Having thus shewn, as far as the matter admits, that the immense quantity of water in the interior part of Africa, accumulated from rain, and carried by the Niger and other rivers near the centre of this continent, cannot be evaporated in small lakes, and still less in the marshes of Wangara, and that it cannot arrive at the ocean by way of the gulf of Guinea, we infer from this the necessity of the existence of a large lake or interior sea. Into this sea the surplus of all the waters left by vegetation and other decompositions of this fluid, roll and unite. It remains now only to advance a few facts in favour of our opinion, that such an interior sea actually exists. Many errors, observes our author, have arisen from the Europeans not comprehending the word Bahar, which they always understood to mean only a lake or river; but the nations who speak Arabic call the sea *Bahar*, a common lake *Bahar*, and a river also *Bahar*. To these remarks Ali Bey has added, in a separate chapter, all the information he received respecting a mediterranean sea, from a merchant of Morocco of the name of *Sidi Matte Buhlal*, who had resided for many years at Tombuctoo, and in other countries of Sudan or Nigritia, the most material of which was, that "Tombut is a large town, very trading, and inhabited by Moors and Negroes, and was *at the same distance from the Nile-Abid* (or the Nile of the Negroes, or Niger) as *Fez* is from *Wad-Sebu;* that is to say, a bout 300 English miles.

"This river *flows towards the east.*

"The Nile-Abid is very large; every year, in the rainy season, *it passes over its bed and inundates the country like the Nile in Egypt,* and it appears then like an arm of the sea.

"The *Nile-Abid takes its direction towards the interior part of Africa, where it forms a vast sea which has no communication with other seas. In this sea the barks of the negroes navigate* 48 *days from one shore to the other, and always without being able to perceive the opposite coast.*

"The most common objects of trade on this sea are salt and corn, as the interior contains some very populous countries which are deficient in these articles.

"It is said that this sea is in connection with the Nile of Egypt, but nothing positive can be ascertained in favour of this supposition.

"It is also said that Houssa, to the east of Tombut, is a very large, populous, and civilized city."

Buhlal, observes Ali Bey, in giving me the above information, spoke Arabic, and always made use of the word *Bahar.* I asked him to explain the sense in which he was taking this word. He told me several times that he meant a sea of several days voyage across, either in its length or its breadth, and resembling *that on which we were then navigating,* (this was the Mediterranean.)

This information removes all doubts on the existence of an interior or African Caspian sea, which Buhlal was always calling Bahar Sudan or Nigritian sea; and this fact, the reader will remark, corresponds with the reasoning founded on physical calculations.

Ali Bey says in another part of his Travels, (Vol. I. p. 42) a Talbe of the name of Sadi-Amkeshet paid me one day a visit, and as we were accidentally conversing on the interior of Africa, he addressed to me the following discourse:

"Frequently caravans set out from the provinces of Sus and Tafilet, and cross the Great Desert in about two months, to go to Ghanu and Tombouctou.

"There are, in the interior of Africa, two rivers called

Nile; the one passes Cairo and Alexandria, the other takes its direction to Tombouctou.

"Travelling from Morocco to the shores of the Nile of Tombouctou is as safe as in the middle of a town, even though you should be loaded with gold; but on the other side of the river there is no justice nor safety, because it is inhabited by nations of very different character. This river contains the fierce animals called Tzemsah, which devour men."

He pointed out with his hand the direction of the courses of these two Niles; "that of Cairo," said he, "runs toward the east;" "and the other, of Tombouctou," replied I, "does that run towards the west?"

"Yes, Seignior," said he immediately, "towards the west."

"How is it possible to reconcile so great a contradiction? All that I heard, proved to me that the trade between the southern countries of Morocco and Tombouctou is very active and continual; it is, therefore, impossible that these people should be mistaken or uncertain about the course of the *Nile of Tombouctou,* as thousands of the inhabitants of Morocco are perpetually seeing it. They all say that this river runs toward the west; at the same time Mungo Park assures us that he saw it flowing towards the east. What must we conclude? Giving to Mungo Park all the credit which he deserves, we must say that there passes to Tombouctou, towards the west, another river, which as yet we do not know, and which these people confound with the great Western Nile, or Joliba, discovered by him, who indeed, declares that this river does not pass actually by Tombouctou. We must suppose that the Joliba makes at this spot a strange winding, which gives to the inhabitants of Morocco the opinion they express; or else we must believe that these people speak without having seen any thing, and only go by the notions of ancient geographers. However, these circumstances, when separated from the errors which surround them, indicate two singularities; viz. *the union or communication of the two Niles at their source, in the same lake, and the loss of the Western Nile in another lake.*"

We extract the following account as being one of the most

interesting parts of the work, and is one of the best specimens of the author's descriptions.

"At two in the afternoon a man dropped down stiff as if he were dead, from his great fatigue and thirst. I stopt with three or four of my people to assist him. The little wet which was left in one of the leather budgets was squeezed out of it, and some drops of water poured into the poor man's mouth, but without any effect. I began to feel that my own strength was beginning to forsake me; and becoming very weak, I determined to mount on horseback, leaving the poor fellow behind.

"From this moment others of my caravan began to drop successively; and there was no possibility of giving them any assistance; they were abandoned to their unhappy destiny, as every one thought only of saving himself. My horse began now to tremble under me, and yet he was the strongest of the whole caravan. We proceeded in silent despair. When I endeavoured to encourage any of them to increase his pace, he answered by looking steadily at me, and by putting his fore-finger to his mouth to indicate the great thirst by which he was affected. Our fate was the more shocking, as every one of us was sensible of the impossibility of supporting the fatigue to the place where we were to meet with water again. At last at about four in the evening I had my turn, and fell down with thirst and fatigue."—Vol. I. p. 189.

"This country is entirely without water; not a tree is to be seen in it; not even a rock which can offer a shelter or a shade. A transparent atmosphere, an intense sun, darting his beams upon our heads, a ground almost white, and commonly of a concave form, like a burning glass, slight breezes, scorching like a flame. Such is a faithful picture of this district through which we were passing.

"We had now neither eaten nor drank since the preceding day; our horses and other beasts were as destitute, though since nine in the evening we had been travelling rapidly. Shortly after noon we had not a drop of water remaining, and the men, as well as the poor animals, were worn out with fatigue. The mules, stumbling every moment

required assistance to lift them up again, and to support their burthen till they rose. This terrible exertion exhausted the little strength we had left.

" Extended without consciousness on the ground in the middle of the desert; left only with four or five men, one of whom had dropped at the same moment with myself, and all without any means of assisting me, because they knew not where to find water, and if they had known it, had not strength to fetch it, I should have perished with them on the spot, if Providence, by a kind of miracle, had not preserved us.

" Half an hour had already elapsed since I had fallen senseless to the ground, (as I have since been told) when at some distance a considerable caravan was seen advancing. Finding us in this distressing situation, the director ordered some skins of water to be thrown over us. After I had received several of them over my face and hands, I recovered my senses, opened my eyes, and looked around me, without being able to discern any body. At last, however, I distinguished seven or eight sheiks and fakers who gave me their assistance, and shewed me much kindness. I endeavoured to speak to them, but an invincible knot in my throat seemed to hinder me; I could only make myself understood by signs and by pointing to my mouth with my finger.

" They continued pouring water over my face, arms, and hands, and at last I was able to swallow small mouthfulls of water. This enabled me to ask, '*Who are you?*' When they heard me speak, they expressed their joy, and answered, '*fear nothing; far from being robbers, we are your friends;*' and every one mentioned his name. I began by degrees to recollect their faces, but was not able to remember their names. They poured over me a still greater quantity of water, gave me some to drink, filled some of my leather bags, and left me in haste, as every minute spent in this place was precious to them, and could not be repaired.

" This attack of thirst is perceived all of a sudden by an extreme aridity of the skin; the eyes appear to be bloody, the tongue and mouth are covered with a crust of the thickness of a crown piece, of a dark yellow colour, an insipid taste, and

of a consistence like soft wax. A faintness or langour takes away the power to move; a kind of knot in the throat and diaphragm, attended with great pain, interrupt respiration. Some wandering tears escape from the eyes, and at last the sufferer drops to the earth, and in a few moments loses all consciousness. These are the symptoms which I remarked in my unfortunate fellow travellers, and which I experienced myself."

Narrative of Robert Adams, *&c.* 4*to. Murray, London,* 1816.

In October, 1810, the American ship Charles was wrecked on the coast of Africa; according to the captain's account, about 400 miles to the northward of Senegal: the crew were made prisoners by the Moors: the place where they landed was called El Gazic. Here they remained for fourteen days, when the Moors departed for the interior. Adams, an American sailor, and two other of the crew, were joined to a party of Moors of about twenty; they travelled at the rate of about fifteen miles a day; route easterly, inclining to the southward. At the end of thirty days they came to a place where there were several tents, and a pool of water; it was the first water they had found since leaving the coast. Here they remained about a month, when Adams and another were compelled to join a party of Moors on an expedition to Soudenny; their route was about S. S. E. the rate from fifteen to twenty miles a day. They were about sixteen days getting there. In their attempt to carry off some of the negroes as slaves, the party were surrounded and taken prisoners: they proceeded easterly at the rate of fifteen and twenty miles a day, then shaping their course to the northward of east, they reached Tombuctoo in fifteen days, at about the rate of twenty miles a day. Here the Moors were imprisoned, but Adams and a Portuguese boy were taken to the king's house, and kept there as curiosities. The king was called *Woollo*, the queen *Fatima, both old and grey-headed.* The *palace* was *built of clay and grass, and consisted of eight or ten small rooms on the ground floor,*

surrounded by a clay wall. In about six months a party of Moors ransomed Adams and their countrymen. Adams was well treated at Tombuctoo, and from the curiosity shown by the natives, believes they had never seen a white man before. He walked about the town as far as two miles south of it: *heard no mention there of the Joliba, though he remembers to have heard of it afterwards at Wednoon; but a large river flows close by Tombuctoo, which is called by the negroes* La-mar-Zarah*: course from the n. th-eastward, about three quarters of a mile wide: supposes Tombuctoo to cover as much ground as Lisbon: houses low, built of sticks, clay, and grass: no stone buildings, no walls, no fortifications: population wholly negroes: fruits, cocoa nuts, dates, figs, pine apples, and a sweet fruit about the size of an apple, with leaves like a peach tree.*

The party left Tombuctoo, skirted the river for about ten days, at the rate of from fifteen to eighteen miles a day, in an easterly direction inclining to the northward: then loading the camels with water, struck off in a northerly direction, and at the end of thirteen days arrived at *Taudenny*, a large village inhabited by Moors and Negroes. Here they remained fourteen days, and then set out to cross the Desert, in a north-westerly direction: it took twenty-nine days. At Woled D'leim, a tented village of Moors, Adams and his companion were employed for ten or eleven months to take care of sheep and goats: from hence Adams got as far as El Kabla, in an attempt to escape to Wed-noon, and on being overtaken by his former master, was bought of him by the chief, Mahomet, who had two wives, one old and one young. Here Adams was employed to watch the *old* wife's goats, but being discovered in an amour with the *young* one, was sold to a Moorish trader, who set out the next day to Woled Aboussebàh, where they arrived in nine days; thence after some delay they went to Wed-noon, where Adams met two of the crew of the Charles, slaves to the governor's son. He was here sold for twenty dollars, and was employed in agricultural labours. Whilst here he was ransomed by Mr. Dupuis, the British Consul at Mogadore. On his arrival at Mogadore, he was kindly received by Mr. Dupuis, who kept him eight

months; he then went to Tangier, and thence to Cadiz, where he remained with Mr. Hall, an English merchant, for eighteen months From Cadiz he went to Gibraltar, and thence to Bristol; and in a passage from Bristol to Liverpool, was put on shore sick at Holyhead, whence he begged his way to London, where he arrived in the month of October last, completely destitute. He was recognised in the streets by a a gentleman, as the late servant of Mr. Hall, and sent to the African Committee.

Such is a short outline of this man's story, which excited much interest. He was unable to write: his narrative was taken down at successive examinations.

Just as this narrative was about to be published, Mr. Dupuis arrived in England. This gentleman read it over, and has made notes on it (which are added); and corroborated the leading circumstances.

This gentleman, who has been some time resident at Mogadore, states, that he has no doubt but that the town in which Adams dwelt with the negroes was Tombuctoo.

There is nothing to be discovered in his conduct which might lead to the supposition that he was an impostor. The impression, however, made by him, at an examination at the house of Sir J. Banks, on the minds of some, we understand, was not favourable to his veracity.

The chief circumstances against the truth of the narrative are his extraordinary account of some objects of natural history; the state in which he represented Tombuctoo, and its being the residence of a negro sovereign instead of a musselman; his description of a great river, La-mar-Zarah, flowing close by it to the south-westward; and lastly, his almost total ignorance of the negro language; these objections are severally combated in an article on this work in the XXVIIIth Number of the Quarterly Review.

ART. XVII. *Some Account of Mr.* Samuel Clegg's *Improvements of the Apparatus employed in Gas Illumination.* *By* WILLIAM THOMAS BRANDE, *Esq. F. R. S. L. and E. Prof. Chem. R. I.*

IN the last number of this Journal I have detailed such facts as I conceived might be generally useful, respecting the application of coal gas to the purposes of illumination. On the present occasion I am enabled by the kindness of Mr. Clegg to describe some new apparatus, and several important improvements which he has successfully adopted at the large establishment at Westminster, belonging to the Gas Light Company.

Since I wrote my former paper upon this subject I have had the superintendance of the construction of a gas apparatus, which the Apothecaries Company have erected at their Hall, near Blackfriars Bridge, and by which their different laboratories and warehouses, as well as the exterior of the building, are now exclusively lighted. I have here learned several facts connected with the production and management of the gas, which are new to me, and which, if verified by future experiments, will be detailed in this Journal.

One of the most important parts of the gas apparatus, and at the same time most difficult of construction, are the gasometers and reservoirs. As these are commonly made, they require a cistern or vessel of water of very large dimensions, in which they are suspended, and rise and fall perpendicularly, as the gas enters and escapes; and it is extremely difficult to prevent leakage, and other accidents, unless very great expense be incurred in their construction, by nicety and solidity of the workmanship. Upon the perfect regularity of their action too, the steadiness and perfection of the flames will materially depend; and owing to the mode of suspension generally employed, this is scarcely attainable where the instrument is of very large dimensions.

The following is a description of a rotary gasometer erected by Mr. Clegg at the Westminster Works, and in which, while

the above objections are in a great measure obviated, several other advantages are incurred: its action is so steady and regular, that it has been found advantageous to suffer the gas to pass through it from the vertical gasometers previous to entering the main pipes for consumption in the streets and houses; and the cistern which it requires is comparatively small. It is represented in Plate III.

Fig. I. A. A. B. B. C. D. E. represents about two thirds of a hollow rim of a wheel, into which the gas is received. The end A. A. is closed, the end C. D. E. is open from D to E; the pipe F. G. H. connects the two ends of the segment or hollow rim, and is made of sufficient weight to counterpoise the whole; this pipe is inserted air-tight into the rim at F, and contains a stop betwixt G and H. At G is joined a pipe forming a communication with the hollow axis O, upon which the rim turns, and which supports it by arms and braces, after the manner of other wheels, and revolves upon a friction sector. I. K. L. M. represents the cistern of water in which the rim is immersed, sufficiently deep to counteract the pressure of the gas.

It must be evident, that the gas being conveyed into the open end of the hollow axis O, which is closed at the opposite end, will proceed by the pipe G. F. into the closed end of the gasometer at F: the operation will be as follows: supposing the closed end A. A. at the surface of the water in the cistern, and the gas flowing in as just described, the end of the gasometer A. A. will begin to fill, and consequently to ascend, and the wheel will continue to move upon its axis until the open end D. E. comes nearly to the surface of the water; and when the gas is required to be discharged, it will return through the same channels by which it entered.

A sufficient power or pressure is given to the wheel for discharging the gas at the velocity required, by means of an adequate weight suspended by a chain over a pully, which chain is fixed to the wheel upon a small circle made fast to the arms near to and round the end of the axis; thus the wheel will retrograde as the gas is discharged, until the end A. A. again arrives at the surface of the water, when the whole of the gas will be discharged.

Plate III. Fig. II. represents an instrument invented by Mr. Clegg, of great importance to the wholesale gas manufacturer: he terms it a gas-meter, or guage, the object of which is to measure by the number of its revolutions, the quantity of gas which passes through it in any given time, and which may be recorded during the observer's absence by a proper index. At present, he who supplies the gas has no direct check upon the consumer; but by connecting this gauge with the pipes of supply, so that the gas entering any building or manufactory, may pass through it, the quantity will be registered, and the charge may then be proportioned to the consumption. A. A. represents a wheel, the air-tight rim of which, or hollow space from B. to B. should be apportioned to the number of burners it is intended to supply: a cubic foot should be allowed for eight Argand burners. This rim is divided into three equal parts C. D. E. by three partitions, two of which are seen at F. G., and a third is placed about H. These partitions are provided with hydraulic scrolls or tubes, so constructed that being supplied with water the communication between the divisions is intercepted when required. The rim is supported from the hollow axis by six hollow arms, three of which conduct the gas entering at I. to the circumference, and three discharge it at the opposite extremity of the axis K., there being a stop or partition about the centre of the axis. The three crooked arms L. M. N. convey the gas to their corresponding divisions, and they are thus contorted to allow them so to contain water in their bends as occasionally to prevent the passage of the gas into certain of the cavities of the circumference, which may be discharging. The three hollow arms, O. P. Q. proceed in a straight line from the centre of each division and being continued along the edge of the rim are inserted into the partition, so as to form a connection, not with the division it appears to enter, but with the preceding one.

The pipe which furnishes the gas is connected at the axis at I. by a tube nearly fitting it, and secured by a semifluid; and the egress pipe is similarly connected to the opposite extremity K.

The scrolls fixed to each side of the division plates are alike.

R. is a scroll of sufficient capacity to allow the water to pass freely through it, but at the same time to prevent the passage of gas. S. is another scroll which will admit the water when descending into it to pass freely, and when the wheel rises out of the water contained in the vessel H. at T. retains so much of it as to stop all communication with the gas contained in the next division, as long as required.

That the water may pass freely through the scrolls, when they enter it, the gas they contain must have free egress, and air should be admitted when they rise out of the water, in order that the water they retain may run to its level; this is effected as follows. To the highest part of each scroll when entering and when rising out of the water is fixed a tube of the following construction.

A. B. C. fig. 3, is a section of a worm pipe of iron or glass, or any material which will retain quicksilver, and which is made tight into another tube at D. inserted into the scroll at A. There is an opening in the worm pipe at T. which forms a free communication between it and the pipe D., and at V. is another opening forming a communication between the worm pipe and the gas in the rim. The operation of this worm pipe is as follows. Suppose a scroll entering the water, and the tube D. at its highest point; the worm pipe will then be nearly vertical, and the quicksilver it contains will be below T. so that the air can pass from V. to T. to and from the scroll; but when the worm pipe changes its position, and it is required that this opening should be closed, as when rising out of the water, the quicksilver will then occupy the bend, B. C., and shut off the communication between T. and V.

The operation therefore of the guage will be as follows. Supposing the wheel in the position represented in the plate, revolving from right to left, and to have made one revolution in the cistern of water, by which the scrolls will have received the water necessary for the performance of their office. There will be a free passage through the bent arm N, into the division E, at the plate at H, which is just rising out of the water, and which, like a gasometer, will continue to rise, until the next division plate comes to the surface of the water; while the division plate is descending the gas is discharged by the

pipes before mentioned at the other end of the axis. It will be observed, that the wheel, in any situation, will always have one of the receiving tubes open, and one of the discharging tubes open, and consequently that it will revolve. A small tube is fixed to the periphery of the rim, for the purpose of admitting water, and keeping it at the same level as that in the cistern; the form of the tube is such as to shut off all communication with the interior of the rim and the external air, when above water, but it remains open while in the cistern.

One of the best purposes to which the tar produced in the distillation of coal can be applied, is to the production of gas, which, as has been stated in my former paper, it yields in the proportion of about eighteen cubic feet from each pound, and of an excellent quality for illumination. The following is an account of Mr. Clegg's apparatus for its decomposition, and which appears to answer better than any yet devised.

A, Plate IV. Fig. I., is a tar cistern. B, a cock, by which it is drawn off. As a sufficiently small stream of tar is apt to stop, by its stiffness, a larger quantity than is wanted is allowed to run into E, upon the edge of the dividing plate C, adjusted by the screw D: the excess runs off by a waste pipe into any proper vessel, while a due portion trickles through E into F., and runs down G. G. into H., where, when the tar has reached the level I., it is conducted into the retort K. L. M. Fig. II, the return of gas being prevented by the immersion of the end of the tube G. G. into the tar in the vessel H. The retort, resembling a bent pipe or syphon, is so inserted in a proper flue, that the ends K. M., provided with lids or mouth-pieces N. O. may be easy of access, and one above the other; the lower branch L. M. may be placed almost horizontally, and the upper should form with it an angle of about ten degrees. The retort being made red hot, the tar will be decomposed, and the gas, and some other products will flow from the end M., by the pipe P., into the vessel Q., in which is a partition plate R. Fig. I., extending about half way down, and allowing the heavy products to accumulate for a convenient time before they can interfere with the passage of the gas, which passes to the purifiers, as usual, by the pipe S. S. T. Fig. II, is a

moveable lid for cleansing the vessel. It is not thought necessary particularly to describe the construction of the furnace, which may be much varied, according as circumstances require.

Art. XVIII. *On the Analogies between the undecompounded Substances, and on the Constitution of Acids. By Sir* H. Davy *LL. D. V. P. R. I. F. R. S. &c.*

In a work published in 1812,* I have pointed out some of the analogies between the substances considered in the present state of our knowledge, as undecompounded, and I have endeavoured to found a classification upon these analogies.

I placed oxygene and chlorine together, because, in combining with inflammable bodies and metals, they produce heat and light in a much higher degree than any other known species of matter, and because many of their compounds are possessed of analogous chemical, and electrical qualities. At the same time I stated, that there is a general chain of resemblance between all the chemical agents, and that while sulphur is analogous to chlorine in one of its properties, it possesses more general resemblances to phosphorus.

The progress of chemical discovery since that time has added new links in the system of analogy, and modified some of the ancient links. The singular body iodine, whilst it strongly resembles chlorine in most of its chemical qualities, is still more analogous than chlorine to sulphur; and in lustre, opacity, specific gravity, and the high proportional quantity in which it unites to other matter, it is similar to the metals. With the metals, indeed, it may be said to be distinctly connected by means of tellurium, which, as I have shewn, by uniting to hydrogene, forms a substance having acid properties.

Carbon, boron, and silicon, appear the links between phosphorus and sulphur and the metals, and probably the basis

* Elements of Chemical Philosophy.

of zircona, glucina, and alumina, will form a part of the chain between the metals of the alkaline earths and the common metals.

Hydrogene and azote stand almost alone; yet hydrogene is connected with the common inflammable bodies by the manner in which it combines with oxygene and chlorine, and azote resembles carbon in the proportional quantity in which it enters into combination, and in its want of attraction for metallic substances. Fluorine probably, if it could be obtained insulated, would form the link between oxygene and chlorine and azote.

M. Gay Lussac, in an elaborate paper published in the Annales de Chimie for July 1814,* in which he has advanced

* The historical notes attached to that paper are of a nature not to be passed over without animadversion. M. Gay Lussac states in these notes, that he and M. Thenard first advanced the hypothesis that chlorine was a simple body, and that he was the first person to demonstrate the nature of iodine; and he quotes M. Ampere as having had before me the opinion that chlorine and fluorine were simple bodies. On the subject of the originality of the idea of chlorine being an elementary body, I have always vindicated the claims of Scheele, but I must assume for myself the labour of having demonstrated its properties and combinations, and of having explained the chemical phenomena it produces; and I am in possession of a letter from M. Ampere, which shews that he has no claim of this kind to make.

With respect to the nature of fluoric acid, still a hypothetical subject, M. Ampere was certainly original; but he formed his opinion in consequence of my views of chlorine; and I had imagined and applied the hypothesis before I had any communication from M. Ampere, and in my paper on the subject I have done all the justice that was in my power to the views of that ingenious academician.

With regard to iodine, the first account I had of it was from M. Ampere, who, before I had seen the substance, supposed that it might contain a new supporter of a combustion. Who had most share in developing the chemical history of that body, must be determined by a review of the papers that have been published upon it, and an examination of their respective dates. When M. Clement shewed iodine to me, he believed that the hydroiodic acid was

many views, reasonings, and calculations, upon the composition of the compounds of chlorine, exactly the same as those I have given in the three papers published three years before in the Transactions of the Royal Society,* endeavours to shew that there is a stronger analogy between chlorine, iodine, and sulphur, than between the same bodies and oxygene; and he wishes them to be separated as a class from oxygene, and placed in a class with sulphur. I do not admit the force of his reasoning on this subject; the bodies to which he refers have only one marked point of resemblance to sulphur, that which I have mentioned above, and they differ from it in their electrical relations, and in the chemical and electrical nature of all their other compounds, and agree in these respects with oxygene Like oxygene in voltaic arrangements, they are determined to the positive surface, whereas sulphur is separated at the negative surface; the compounds they form with metals strongly resemble those formed by oxygene; they are electric, and many of them soluble in water and possessed of acid properties; whereas those formed by sulphur are all non-electrics and insoluble

I cannot admit M. Gay Lussac's views on the classification of the undecomposed substances, nor can I adopt his ideas respecting their properties as chemical agents. He considers hydrogene as an *alkalizing* principle and azote as an *acidifying* principle. This is an attempt to introduce into chemistry a doctrine of occult qualities, and to refer to some mysterious and inexplicable energy what must depend upon a peculiar corpuscular arrangement. If hydrogene be an alkalizing principle, it is strange that it should form some of the strongest acids by uniting to bodies not in themselves acid; and if azote be an acidifying principle, it is equally strange that it should form

muriatic acid; and M. Gay Lussac, after his early experiments made originally with M. Clement, formed the same opinion, and *maintained it*, when I *first* stated to him my belief that it was a new and peculiar acid, and that iodine was a substance analogous in its chemical relations to chlorine.

* Philosophical Transactions, 1810, 1811.

nearly $\frac{9}{10}$ of the weight of the volatile alkali. It is impossible to infer what will be the qualities of a compound from the qualities of its constituents; and if M. Gay Lussac's views were correct, the prussic basis of azote and carbon ought to have its acid properties diminished, and not increased, as he has proved them to be, by combination with hydrogene.

When certain properties are found belonging to a compound, we have no right to attribute these properties to any of its elements to the exclusion of the rest, but they must be regarded as a result of combination.

When M. Gay Lussac assumes that oxygene and hydrogene, in the proportions in which they form water, are passive as elements of a combination, it is a *pure assumption*, and opposed to the whole series of chemical facts. Hydrogene with chlorine forms a strong acid; oxygene with phosphorus forms a strong acid; and supposing water combined with the compound of phosphorus and chlorine, the results contain two of the most energetic known acids: phosphorane does not redden litmus paper, but if it be dissolved in water it becomes a solution of muriatic and phosphorus acids.

If oxygene and hydrogene, in the proportion in which they form water, are to be considered as passive, as neutralizing each other in all combinations in which they exist, then almost all the vegetable acids must be considered as acids of carbon, which, though containing much less oxygene than carbonic acid, and some of them less even than carbonic oxide, have yet strong acid powers.

I have discovered a gaseous combination of four proportions of oxygene and one of chlorine, which has no acid properties. M. Gay Lussac has discovered a compound of two proportions of hydrogene, one of chlorine, and six of oxygene, which has acid properties; but he considers this substance merely as chlorine acidified by oxygene, and neglects the hydrogene, without which he allows, however, it cannot exist. He supposes that this acid of one proportion of chlorine and five of oxygene exists in all the hyper-oxymuriates, but he does not support his supposition by any proof. The hyper-oxymuriates are, as I shewed six years ago, composed of one proportion of

chlorine, one of a basis, and six of oxygene. Hydrogene, in M. Gay Lussac's chloric acid, may be considered as acting the part of a base; and it is an important circumstance in the law of definite proportions, that when one metallic or inflammable basis combines with certain proportions of a compound, all the others combine with the same proportions.

M. Gay Lussac states, that if the chloric acid be not admitted as a pure combination of chlorine and oxygene, neither can the nitric or sulphuric acids be admitted as pure combinations of oxygene. This is perfectly obvious. An acid composed of five proportions of oxygene and one of nitrogene is altogether hypothetical; and it is a simple statement of facts to say, that liquid nitric acid is a compound of two proportions of hydrogene, one of azote, and six of oxygene; and, as I shewed long ago, the only difference between nitre and hyper-oxymuriate of potash is, that one contains a proportion of azote and the other a proportion of chlorine.

There are very few of the substances which have been always considered as neutral salts, that really contain the acids and the alkalies from which they are formed. The muriates and the fluates must be admitted to contain neither acids nor alkaline bases. Most of the prussiates M. Gay Lussac has lately shewn are in the same case. Nitric and sulphuric acids cannot be procured from the nitrates and sulphates without the intervention of bodies containing hydrogene; and if nitrate of ammonia were to be judged of from the results of its decomposition, it must be regarded as a compound of water and nitrous oxide.

Only those acids which are compounds of oxygene and inflammable bases appear to enter into combination with the fixed alkalies and alkaline earths without alteration, and it is impossible to define the nature of the arrangement of the elements in their neutral compounds. The phosphate and carbonate of lime have much less of the characters attributed to neutrosaline bodies than calcane (muriate of lime), and yet this last body is not known to contain either acid or alkaline matter. The chloriodic acid, the phosgenic acid, and the binary acids containing hydrogene, combine with ammonia without decomposition, but

they appear to be decomposed in acting upon the fixed alkalies or alkaline earths; and yet the solid substances they form have all the characters which were formerly regarded as peculiar to neutral salts consisting of acids and alkalies, though they none of them contain the acid, and only the two first of the series the alkalies from which they are formed.

The substitution of analogy for fact is the bane of chemical philosophy; the legitimate use of analogy is to connect facts together, and to guide to new experiments.

As I cannot adopt M. Gay Lussac's opinions, so neither can I approve of his nomenclature. To call the compounds of chlorine and iodine, chlorures and iodures, is to place chlorine and iodine in the class of inflammable bodies, and I prefer to these denominations chlorides and iodes. M. Gay Lussac has called sulphuretted hydrogene, hydrosulphuric acid; a term which has already been applied to sulphuric acid, the oil of vitriol of commerce. Hydro-chloric acid would signify chloric acid combined with water, and therefore, according to M. Gay Lussac's own views, is more applicable to his chloric acid than to muriatic acid.

ART. XIX. *On the Prussic Basis and Acid. By Sir* H. DAVY, *LL.D. V.P.R.I. F.R.S. &c.*

In the last article I have defended some opinions of my own, and combated some of M. Gay Lussac's. In this article, the object I propose is one much more agreeable to my feelings; to offer my experimental confirmation of the very elaborate and ingenious researches of M. Gay Lussac on the prussic acid, and the prussic base.

The prussic acid (hydrocyanic acid) was procured by Mr. M. Faraday by M. Gay Lussac's process, and I found it of specific gravity, rather below .7. On electrizing this acid in the Voltaic circuit, by wires of platinum, it afforded oxygene at the positive surface, and hydrogene in about twelve times the

volume at the negative surface. This at first led me to suspect the decomposition of azote: but on continuing the experiment for several hours, the production of oxygene ceased, and a compound of platinum and cyanogen was found at the positive pole, and hydrogene was given off at the negative pole; so that there was every reason to suppose that the oxygene arose from a minute portion of water, which could not be separated by muriate of lime.

By heating prussiate of mercury in muriatic acid gas, I obtained pure liquid prussic acid and corrosive sublimate.

I burnt a large quantity of cyanogene, freed from prussic acid by red oxide of mercury, slowly in oxygene gas, and cooled the product by a freezing mixture; but no water was deposited.

I decomposed cyanogene by passing electrical sparks through it; when it gave its own volume of azote, and deposited charcoal.

I shall not detail any experiments of research on a subject which is peculiarly M. Gay Lussac's, but I shall venture to point out to him a mode which I have found successful of procuring combinations of cyanogene; that of heating bodies with prussiate of mercury. In this way, compounds of the prussic radicle with iodine, sulphur, and I believe with phosphorus, may be formed. The compound of iodine is a very curious body; it is volatile at a moderate heat, and on cooling collects in flocculi, adhering together like oxide of zinc formed by combustion, and it has a very acrid taste and pungent smell.

I wish M. Gay Lussac could be prevailed upon to give up the inexpressive and difficult names of cyanogen and hydrocyanic acid, and to adopt the simpler ones of prussic gas and prussic acid.

Art. XX. *Proceedings of the Royal Society of London.*

Feb. 29. A paper was communicated by Mr. Ivory, containing an investigation of the theory of capillary attraction, a subject which, notwithstanding the numerous and important experiments that have been made upon it, still remains in much obscurity. Mr. Ivory advocates the Newtonian hypothesis, and adduces several proofs of the correctness of Mr. Leslie's enquiries, published in the year 1802 in the Philosophical Magazine. The paper contained a series of mathematical investigations relating to the subject, which were not of a nature to be read before the Society.

The reading of a letter from Dr. Brewster to the President was commenced, and continued during two successive sittings, "on the communication of double refraction to glass and "other substances, by mechanical compression." (See the next article.)

March 14. A Paper by Charles Babbage, Esq. F. R. S. was received, containing further remarks on the calculus of functions; the details were not such as could be entered into at a public meeting of the Society; the paper, therefore, was merely announced.

March 21. Sir Everard Home communicated some experiments to ascertain the mode of action of specific medicines: they related principally to that singular and efficacious remedy, the eau medicinale d'Husson. A variety of facts and statements were adduced, to prove that these medicines produce their effects by entering the blood, and acting directly upon the affected parts. Thus, mercury requires to be received into the circulation, before it can act upon the syphilitic virus, or remove the primary symptoms ot the disease; and the eau medicinale must enter the blood before it can remove the gout. Mercury, and the eau d'Husson, are regarded as the only two known specifics; and it is assumed, though we think that farther researches are required to give firmness to the conclusion, that the eau medicinale is a vinous infusion of the roots of *Colchicum autumnale*, or meadow saffron. In the course of his communication Sir Everard throws out some curious

hints upon the modus operandi of other medicines. Some acting upon the secretions of the stomach, and thus indirectly modifying the constitution of the blood; while others produce their effects in consequence of direct mixtures with that fluid. This is sometimes the case where we should least expect it. An infusion of ipecacuanha thrown into a vein excites vomiting, and opium produces drowsiness; and colchicum sickens, and perhaps cures the gout. Is it legitimate hence to infer, that all these medicines, when taken into the stomach, are inert till they are received into the blood, and distributed to the parts upon which they produce sensible effects?

A paper on the composition and combinations of phosphoric acid, by Thomas Thomson, M. D. was commenced, and concluded at a succeeding meeting. According to Lavoisier's original researches, one part by weight of phosphorus unites to one and a half of oxygen to constitute phosphoric acid, a result which has been verified by several succeeding chemists, and more especially by Sir Humphry Davy, who regards this acid as composed of 20 phosphorus + 30 oxygen. But, according to the present analyst, 100 phosphorus unites only to 123.46 oxygen to produce phosphoric acid. Rose found the quantity of oxygen yet smaller. Dr. Thomson verifies his conclusion by reference to the analysis of phosphate of lead, and by taking a mean of methods, ultimately considers phosphoric acid as consisting of 100 phosphorus + 123,37 oxygen He then proceeds to examine the compounds which the phosphoric acid produces by combining with lime, the phosphates of lime, of which, he conceives, there exist no less than six varieties, each of definite constitution: they bear the following names, 1. Quadrosteo-phosphate; 2. Binosteo-phosphate; 3. Bige-phosphate; 4. Osteo-phosphate; 6. Ge-phosphate. The constituents of many other phosphates are detailed in this communication; but as it would be indecorous to criticise a paper not published, and as without criticism the details would be of little avail, it is unnecessary at present to pursue them. Dr. Thomson infers from his numerous experiments, that the atomic doctrines of Berzelius are not worthy the confidence which he once put in them.

Art. XXI. *Proceedings of the Royal Society of Edinburgh.*

Apr. 1. Dr. Murray communicated some additional Remarks on the Construction and Use of a Lamp for illuminating Coal Mines. The lamp was exhibited: It is well calculated for giving a strong steady light, and from being supplied with air from a tube reaching to the floor, affords great security.

Apr. 15. Dr. Murray communicated the first part of a Paper on the Analysis of Sea Water. The methods employed were suggested by the views formerly delivered in Dr Murray's paper on the analysis of the mineral waters of Dumblane, and the conclusions were conformable to these views.

April 29. Mr. Hugh Murray read an essay "On the Ancient Geography of Central and Eastern Asia, with Illustrations, derived from recent Discoveries in the North of India." Mr. M. conceived that the ancients, particularly Ptolemy and Pliny, knew more respecting this quarter of the world than is generally supposed. The modern discovery respecting the course of the rivers of the Punjab, and their union into one, before falling into the Indus, is a mere restoration of Ptolemy's map of these rivers. The western tributaries, so erroneously delineated by the moderns till the Caubul mission, are represented by him with nearly equal precision. Mr. M. conceives that Ptolemy's statements, carefully analysed, form a pretty correct outline of central and eastern Asia. Thus the extensive tract of the Sacarum Regio, bounded on the south by India, from which it is separated by the Imaus (Hemalleh), corresponds in all its features with Little Thibet. Scythia extra Imaum, bounded by India beyond the Ganges, from which it is separated by the Mons Emodus, will then be Great Thibet, extended indefinitely into Tartary. Serica, then, bounded on the south partly by India beyond the Ganges, and partly by Siam (Sinarum Regio), will, under some modifications, be China. The very character of the Seres, mild, timid, unwarlike, jealous of foreigners, and carrying on trade only at fixed frontier stations, represents exactly and exclusively the modern Chinese. Mr. M. then endeavours to show, that the

prevailing systems of d'Anville, Gosselin, &c. are founded on an undue contempt of ancient authorities, and upon some slight resemblances of name, which, compared with the grand and permanent features of nature, cannot be allowed much weight in such an investigation.

At the same meeting Dr. Brewster laid before the Society a Paper on a new optical and mineralogical Property of calcareous Spar. Having formerly shewn (Phil. Trans. 1815, p. 270) that the colours exhibited by some specimens of calcareous spar were produced by a thin film or interrupting stratum which divided the polarised light into its complementary tints; Dr. Brewster examined several new specimens which possessed this property, in order to ascertain the axes of this film. In the course of this examination he discovered that a prism could be cut out of a rhomboid of this kind, which, when combined with another prism of common calcareous spar, exercised such an action upon the transmitted light, that the combined prisms possessed none of the properties described by Huygens and Newton, that is, *none of the four images vanished in any position of the second prism, but continued visible during the whole of its revolution.* The combined prisms however recovered their usual property when the opposite face of the first prism received the incident pencil. Hence it follows, that the pencils were depolarised by the interrupting film; and Dr. B. has shewn that the film has all its axes constantly inclined 45° to those of the mass which contains it. As the particles of the film are not symmetrically combined with those of the mass, they are not joined by their poles, and consequently they do not come into optical contact, light being always reflected at the junction. Some specimens possess two and even three sets of films or veins, each set being parallel to the common sections of the three surfaces which contain the solid angle.

May 6. Dr. Brewster read a Paper "on the Communication of double Refraction to Glass, and other hard and soft substances that refract singly, by mechanical Compression and Dilatation." Having inferred from the optical properties of heated glass, that its doubly refracting structure was owing to a

variation of density, Dr. B. endeavoured, by means of screws, to produce the same mechanical change upon glass, and he found that in every case the glass was converted into a doubly refracting crystal while the pressure was continued. He next took long plates of glass with polished edges, and found that by slightly bending them with the hand, the convex or dilated side had the same structure as one class of doubly refracting crystals, while the concave or compressed side had the same structure as the other class. Muriate of soda, fluor spar, diamond, obsidian, semi-opal, horn, tortoise shell, amber, gum copal, caoutchouc, rosin, phosphorus, the crystalline lens, and the sclerotic coat of fishes, and other substances that have not the property of double refraction, receive it by compression or dilatation; while no effect whatever is produced upon doubly refracting crystals by the most powerful pressure. Many curious results were obtained by inclosing the glass in fluid metal and observing the changes which it underwent from the contraction of the metal in cooling. Upon the preceding principles is founded a *chromatic dynamometer* for measuring the intensity of forces, and various instruments for indicating differences of humidity and temperature by the expansions or contractions which they produce.

The second part of this paper related to the communication of double refraction either transiently or permanently to animal jellies, by gradual induration, or by mechanical compression or expansion.

It follows from these principles that in all crystals of one class there is a difference of density related to the axis; that in those of the other class, the difference of density is related to a line at right angles to the axis; and that in those crystals which have the structure of both classes the difference of density is related to two rectangular axes.

May 20. The conclusion of Dr. Murray's Paper on the Analysis of Sea Water was read.—He gave also the result of an analysis of a salt which is formed in the large way from the brine of sea water, which seems hitherto to have escaped observation. It is a sulphate of magnesia and soda which crystallizes in very regular rhombs, occasionally truncated on some

of the edges and angles. It contains a much smaller quantity of water of crystallization than either sulphate of soda or sulphate of magnesia; is less disagreeable to the taste, and differs from both in all its other properties. It has not hitherto been applied to any useful purpose, but it may probably form a very excellent purgative salt.

A Barometer was exhibited to the Society with a communication from Mr. Kennedy, suggesting a mode of rendering this valuable instrument more portable, and less liable to damage by the concussion of the mercury against the upper part of the tube: this it is proposed to prevent by introducing a small bell-shaped bulb of glass, attached to a spiral spring and fastened to the top of the tube. This improvement appears to be calculated to prevent the accidents which so frequently occur in the use of this instrument.

Dr. Gordon communicated certain observations to the Society, tending to establish the pathological fact, that the appearance called the *buffy coat*, or *inflammatory crust*, is not confined to venous blood, but is also occasionally seen on arterial blood, in similar states of the system. Dr. G. had himself an opportunity of seeing this appearance on arterial blood in one instance; and three other instances, in which it had occurred, were mentioned to him by Dr. Gregory, Mr. Ashburner, and Mr. Wishart.

Dr. Gordon also stated to the Society, that by a series of observations on the muscles of the living human body, during surgical operations,—on the muscles of limbs immediately after amputation,—and on the muscles of several of the lower animals, in a variety of circumstances, he conceived he had established, that the muscular fibre, during its contraction, does not exhibit the slightest appearance of rugæ, but remains perfectly straight; and that it does not undergo any perceptible enlargement in its transverse diameter.

May 27. Mr. Mackenzie read a Criticism on the Tragedy of Bertram lately published by Mr. Maturin.

June 3. Mr. Alison read a Part of a Memoir on the Life and Writings of the late Lord Woodhouselee.

A Paper by Mr. Cadell was read, "on the Lines that divide each semi-diurnal Arc into Six equal Parts."

The intertropical parts of these lines for the climates of Greece and Italy constitute the hour lines on the antique sun-dials. Most of the writers on gnomonics have considered these lines as great circles; Clavius alone demonstrates that they are not great circles: and afterwards Montucla states, but without discussion, that they are curves of a peculiar nature. The celebrated and profound astronomer Delambre, having examined only the portions that occur on the Greek dials, controverts the opinion of Montucla.

The object of the Paper is to shew that the curved surfaces, whose sections form these lines, are undulated, and of the nature of cones, the apex of one undulation being as much elevated above the equator as the apex of the next undulation is depressed below it.

To see the curvature of these lines it is sufficient to draw them on a globe; and the undulated cone is completed by conceiving the diameter of the sphere, which has described the first branch, to move progressively and continuously between the two parallels that touch the horizon, until the extremities of the diameter arrive at the points from which they set out.

If it be proposed, for example, to draw on a globe the curve which contains the third and ninth antique hour line, that the figure may be more conveniently delineated, elevate the pole about 60°, and divide each semi-diurnal arc into two equal parts, a line drawn through the points of division is one bicrural branch of the curve; this branch terminates at a point in the greatest, always seen parallel; and to complete the curve the semi-diurnal arcs belonging to this point, considered as the mid-day point of a horizon, (forming the same angle with the equator as the first horizon, but on the other side), are to be divided into two equal parts, and the points of division being joined, a complete re-entering curve is formed on the surface of the sphere. A diameter of the sphere revolving, with its extremity applied to this curve, forms the undulated conical surface; the portion of the diameter on the other side of

the centre forms at the same time an opposite cone equal and similar.

The five undulated surfaces, each of which contains a pair of the antique hour lines, have each a different number of undulations.

At the same meeting a Paper was read by Dr. Jackson of St. Andrews, containing an elementary Demonstration of the Composition of Pressures.

June 17. Dr. Murray read a Paper entitled " A general Formula for the Analysis of Mineral Waters." The object of the paper was to give one method applicable to the analysis of all waters, instead of the diversity of methods hitherto employed.

Dr. Brewster laid before the Society a notice respecting some new discoveries on light. He found that water exists in nitrate of potash in the state of ice;—that the division of the pencil in doubly refracting crystals is produced by strata of different refractive powers; that one of the images becomes nebulous, as in the agate, when one set of the strata is broken down and irregularly dessiminated among the other strata; and that in certain crystals any one of the two images may be rendered nebulous, or may even be extinguished by a particular process. This notice contained also a general view of the distribution of the polarising influence in tubes and cylinders of glass.

Art. XXII. *Miscellaneous Intelligence.*

I. *On the Bad Effects of the Incautious Use of Magnesia. By* Everard Brande, *Esq.*

At a time when domestic empiricism is so prevalent as at present, it is important to point out the dangers which may arise from the uses, or rather the abuses of the most simple remedies.

Every medical practitioner must have repeatedly witnessed the serious, and sometimes the fatal consequences attendant upon the imprudent use of the stronger medicines, which are

so extensively supplied for family consumption, particularly preparations of antimony, mercury, and opium, which, under a great variety of seducing forms and titles, are constantly employed; generally, however, they are, I believe, not sufficiently aware of the prejudicial effects of the too liberal use of magnesia; either those which may arise from its chemical action upon the urine, which are more immediately observable and common, or which may arise from its mechanical action, as an extraneous insoluble substance, and which are more remote, obscure, and rare.

I need not dilate upon the former, but may refer to my brother's observations upon that subject, published in the Philosophical Transactions for the year 1810, which, I regret, are too little attended to; and with respect to the latter, shall confine myself to the recital of the following case.

A lady was recommended to take magnesia, in consequence of some very severe nephritic attacks, accompanied with the passage of gravel. She was desired to take a tea-spoonful every night; and Henry's calcined magnesia was preferred, as that always operated upon the bowels and "carried itself off," which other magnesia did not, but, on the contrary, felt heavy and uneasy in the stomach. The dose was gradually encreased to two tea-spoonfuls, in order to produce effect upon the bowels, which this quantity never failed to do; the symptoms for which it was ordered were soon removed, but the plan was persevered in for two years and a half, with little intermission or irregularity; so that as the average weight of a tea-spoonful is at least forty grains, and the average dose was a tea-spoonful and a half, it may be presumed that she took during the above period between nine and ten pounds troy.

In the course of the last autumn she suffered severely by a miscarriage, and shortly afterwards by an attack of biliary calculi; subsequent to which she became sensible of a tenderness in the left side just above the groin, connected with a deep seated tumour, obscurely to be felt upon pressure, and subject to attacks of constipation, with painful spasmodic action of the bowels, tenesmus, and a highly irritable state of stomach; these attacks recurred every two or three weeks, varying in

violence, but requiring the use of active remedies; during one of them, about the middle of last March, a large quantity of sand was voided by the rectum, attended with a peculiar acute and distressing pain in the seat of the tumour above mentioned. This was lost. The following day, however, the same kind of evacuation happened again, and to the same extent, which being saved and measured, was found to amount to two pints. Another attack took place upon the 5th of April, when several irregular lumps of a soft light brown substance were voided, having the appearance of a large mass broken down, and when dry extremely friable: a part of each of these two last were subjected to a careful analysis, and found to consist entirely of sub-carbonate of magnesia concreted by the mucus of the bowels, in the proportion of about 40 per cent.

The use of magnesia was now given up, and that of an active purgative medicine enjoined, with some other necessary directions, and there is every appearance of returning health, although some slight attacks have recurred, and small portions of the same concretion still occasionally come away.

An instance, in many respects resembling this, has lately occurred in the practice of some gentlemen of eminence in this town, in which not only large quantities of a concretion of a similar description were voided, but upon examination after death, which took place perhaps six months after any magnesia had been taken, a collection, supposed to be from four to six pounds, was found embedded in the head of the colon, which was of course much distended. Some notes which were made of this case are, I fear, not to be found.

1.I *On the Effect of Heat and Cold on the Colours of Natural Bodies.*

Some time ago a curious fact was observed by M. Thenard, in the course of some experiments on phosphorus. He found that when a piece of purified phosphorus, of a pale yellow colour, was melted in hot water, and then plunged into cold water, it became perfectly black, and always recovered its original colour upon being remelted. This interesting fact

was confirmed by M. Biot, and shows that the colours of natural bodies may depend upon the mechanical condition of their component particles.

Some years ago an analogous fact was observed by Dr. Brewster in realgar. In preparing prisms of this substance, by melting it between plates of glass, he remarked, that this mineral, which has naturally a dark orange red colour, became of a darker hue as the heat increased, till at a certain temperature it grew perfectly black. It always, however, resumed its original colour upon cooling. When in its blackest state, and just before it begins to flame, it was immersed in cold water, but its black colour was not capable of being fixed in this manner. The immersion tended only to make it resume more rapidly its original hue.*

III. *United States of America.*

A new and enlarged edition of the Elements of Botany, in 2 vols. 8vo. by the late Professor Barton, of the University of Pennsylvania, has just appeared at Philadelphia.

A Dissertation on the Pathology of the Human Fluids, by Jacob Dyckman, M. D., has lately been published in New York. The author, a graduate of the university of that state, has entered into an elaborate and able examination of the condition of the circulating fluids, and of the secretions of the human system, both in health and disease; whether the solids or fluids are primarily affected, and how far these latter are ever the subject of morbid action. He investigates, at considerable length, the manner in which the poison of disorders of an acknowledged contagious character, assimilates the body unto their own peculiar nature, and terminates the enquiry by noticing those affections which arise from plethora, or a preternatural quantity of the circulating mass. With becoming feeling the author animadverts upon the opinions of those

* Nitrous acid gas when exposed to heat, has the intensity of its orange colour greatly augmented, so as to appear nearly black. (Editor).

who have considered the solids as alone susceptible of diseased changes, and from the pathological knowledge derived from the most eminent of the ancient and modern autherities in medicine, and from the recent facts which animal chemistry furnishes, he is led most satisfactorily to the conclusion, that the fluids, equally as the solids, are vitiated by disease. Dr. D. acknowledges himself to be largely indebted, for his patholo- researches to the Professor of the Practice of Physic in the University in which he received his education.

Volumes II. and III. of the second series of the Collection of the Massachusett's Historical Society have also been published. These volumes, like those of the former series, contain much valuable information relative to the early history of the American States.

The New York Historical Society, incorporated in 1809, for the purpose of preserving whatever documents relate to the Natural, Civil, Literary, Medical, and Ecclesiastical History of the United States, but more particularly of the State of New York, have laid before the public the second volume of their Collections. The volume is rich in matters interesting to the American reader, and the discourse from the Hon. D. Clinton affords a most valuable account of the Confederates, or Five Nations of Indians, who have been emphatically denominated, by European authors, *the Romans of the Western World.* The discourse delivered before the Society by Dr. Mitchell, will be consulted by all desirous of becoming acquainted with the progress of botanical science in America.

The State of Pennsylvania, imitating the example of that of New York, are adopting measures for the purpose of establishing a Botanic Garden.

At the public examination held in May last, at the College of Physicians and Surgeons of the university of New York, the degree of Doctor of Medicine was conferred on twenty-seven students of that institution.

The Society for the promotion of Useful Arts in the State of New York have completed the publication of the third volume of their Transactions. The Address, by Dr. Beck, on the mineralogical resources of the United States, with their

various applications to the arts and manufactures, is a paper of singular interest, and cannot fail to engage the attention of all who are connected with the establishment of manufactories. The author seems to have been somewhat cautious in his remarks on the influence which institutions of this kind may ultimately have upon the morals and happiness of the American people.

The third volume of the Transactions of the Agricultural Society of Philadelphia, lately printed in large 8vo., is a present to the useful arts of no common value.

IV. *A Letter on the Practical Application of the Wire-gauze Safe-lamp, from* John Buddle, *Esq. to Sir* H. Davy, *LL.D. V. P. R. I. &c.*

Walls-end Colliery, 1st June, 1816.

SIR,

After having introduced your safety-lamp into general use in all the collieries under my direction, where inflammable air prevails; and after using them daily in every variety of explosive mixture for upwards of three months, I feel the highest possible gratification in stating to you, that they have answered to my entire satisfaction.

The safety of the lamps is so easily proved, by taking them into any part of a mine, charged with fire-damp, and all the explosive gradations of that dangerous element, are so easily and satisfactorily ascertained by their application, as to strike the minds of the most prejudiced with the strongest conviction of their high utility; and our colliers have adopted them with the greatest eagerness,

In the practical application of the lamps, scarcely any difficulty has occurred. Those of the ordinary working size, when prepared with common cotton wick and the Greenland whale oil, burn during the collier's *shift*, or day's work of six hours, without requiring to be replenished; and the safety trimmer answers the purpose of cleaning, raising, and lowering the wick completely.

The only inconvenience experienced arises from the great quantity of dust, produced in some situations by working the coal, closing up the meshes of the wire-gauze, and obscuring the light; but the workmen very soon removed this inconvenience by the application of a small brush.

We have frequently used the lamps where the explosive mixture was so high as to heat the wire gauze red hot; but on examining a lamp which has been in constant use for three months, and occasionally subjected to this degree of heat, I cannot perceive that the gauze cylinder of iron wire is at all impaired. I have not, however, thought it prudent, in our present state of experience, to persist in using the lamps under such circumstances, because I have observed, that in such situations the particles of coal dust, floating in the air, fire at the gas burning within the cylinder, and fly off in small luminous sparks. This appearance, I must confess, alarmed me in the first instance; but experience soon proved that it was not dangerous. As it is, however, possible that some other light combustible substance, capable of inflaming at a red heat, may occasionally float in the atmosphere of the mine, I have thought it prudent, for the present at least, to discontinue the use of the lamps where the gauze is subject to that degree of heat, especially if for a length of time at once.

Our colliers have found it most convenient to hang the stationary lamps from small wooden pedestals; but on observing, that where the side of the lamps have been suffered to come in contact with the pedestals, the wood is charred to a considerable depth by the heat of the lamps; I have thought it right to use small iron pedestals instead of the wooden ones.

Beside the facilities afforded by this invention to the working of coal mines, abounding in fire-damp, it has enabled the directors and superintendants to ascertain with the utmost precision and expedition, both the presence, the quantity, and the correct situation of the gas. Instead of creeping inch by inch with a candle, as is usual, along the galleries of a mine suspected to contain fire-damp, in order to ascertain its

presence, we walk firmly on with the safe lamps, and with the utmost confidence prove the actual state of the mine. By observing attentively the several appearances upon the flame of the lamp, in an examination of this kind, the cause of accidents which have happened to the most experienced and cautious miners is completely developed; and this has hitherto been, in a great measure, matter of mere conjecture.

When the discharge of inflammable air is regular, and the density of the atmosphere continues uniform, the firing point may be judged of, and approached with safety by a common candle. But when the discharge of inflammable air is irregular, or the atmosphere is in an unsettled state, a degree of uncertainty and danger attends the experiment of ascertaining the state of a mine. With the safe lamp, however, it is reduced to the utmost certainty, the actual presence and position of the gas is not only ascertained with the greatest precision, but also every alteration of circumstance or position is distinctly perceived.

By placing a lamp near the spot where a quantity of inflammable air is issuing, and mixing with the circulating current of atmospherical air to the firing point, it will be seen that very remote causes frequently produce pulsations in the atmosphere of the mine, which occasion the gas to fire at *naked* lights; thus showing clearly the instability of the element with which we have to deal, and the reason why so many explosions have occurred where lights have not approached the place where the gas was lodged within a considerable distance.

Objections have been made by some who have not had experience of the lamps, to the delicacy of the wire-gauze, under the apprehension that it may be very soon impaired by the flame within the cylinder. Of this, however, I have no reason to complain, as, after three months constant use, the gauze has not, in the hands of careful workmen, been perceptibly injured by the action of the flame; but the outer top gauze of one or two of Newman's making has been worn through by the friction of the rivet on the bottom of the swivel, to which the finger ring is fastened; but this only happened to the lamps used by the *wastemen*, whose business it is to travel

daily in the various avenues of the mines, for the purpose of keeping the passage for the current of air free from obstructions: nothing of the kind has happened to the stationary lamps used by the colliers. In short, I do not apprehend that the gauze can be injured by any ordinary cause without being observed in time sufficient to prevent accidents; and that we have no danger to apprehend, except from the gross negligence of some heedless individual, or an accident of a very unusual description, occurring to injure the gauze.

I find that I have extended my letter to a greater length than I intended; but I trust, Sir, that you will excuse me for having gone so much into detail, as I feel peculiar satisfaction in dwelling upon a subject which is of the utmost importance not only to the great cause of humanity, and to the mining interest of this country, but also to the commercial and manufacturing interests of the United Kingdom: for I feel convinced that by the happy invention of the safe-lamp, large proportions of the coal mines of the empire will be rendered available, which otherwise might have remained inaccessible—at least without an invention of similar utility, it could not have been wrought without much loss of the mineral, and risk of life and capital.

It is not necessary that I should enlarge upon the national advantages which must necessarily result from an invention calculated to prolong our supply of mineral coal, because I think them obvious to every reflecting mind; but I cannot conclude without expressing my highest sentiments of admiration for those talents which have developed the properties and controlled the power of one of the most dangerous elements which human enterprize has hitherto had to encounter.

I have the honour to be, &c. &c.

JOHN BUDDLE.

V. *Observations on the preceding Letter, by Sir* H. Davy.

The intelligence and candour of Mr. Buddle's communication cannot fail to impress every unprejudiced mind; and no testimony can have more weight with practical men.

From conversations that I had with him and with the Rev. John Hodgson, I understood that the lamps would be very

rarely exposed to the most explosive mixture of the fire-damp for more than a few minutes together; but the exposure for hours even cannot be dangerous; though supposing a lamp to be constantly used in a mixture which renders the wire red hot, the precaution of a double cylinder is proper, and I have had lamps of this kind constructed, and have sent the models to Mr. Buddle.

The fear so naturally expressed by Mr. Buddle of any light combustible substance firing at the outside of the lamp when the gas is burning within, the experiments which I have made must entirely dissipate. The finest coal dust, powdered rosin, lycopodium (witch meal), powdered pyrites, have been sent through the lamp and against the wires, when the most explosive mixture was burning within; and though a great blaze was always produced, yet explosion could never be communicated to the outward atmosphere, and the effect was merely an increase of light.

Phosphorus and sulphur are the only common inflammable substances which can communicate explosion by being brought in contact with the outside of the lamp; and sulphur, to produce this effect, must be applied in large quantities, and blown upon by a current of fresh air: and there is no possibility that the miner should ever make so fatal an experiment.

The objections that the wire-gauze will burn out, are shewn to be nugatory by Mr. Buddle's communication. I kept a lamp burning for more than an hour in the most explosive mixture of coal gas, the lowest part of the gauze soon gained a dull red heat which did not increase; no part was at all injured: and the same lamp had been at least fifty times before subjected to similar trials for a shorter time.

The thickness of the wire may be trebled without any other disadvantage than that of a certain diminution of light; but as the wire at present used is not found to be injured, this increase of thickness seems unnecessary.

The rivet at the bottom of the swivel in Newman's lamps is not now made moveable; so that the friction against the wire cannot take place.

The lamps cannot be broken or even crushed, except by intentional violence; and pieces of coal of 100lb. may fall upon

them when they are properly made, without extinguishing the light.

Wire gauze has been adopted, because it is cheaper and more easily made than perforated plates of metal; but if the objections which a few ignorant persons have urged to wire-gauze, had really been valid, the principle of safety would have had another unimpeachable application, and plates of copper or tinned iron perforated with numerous small apertures surrounding the flame, would have transmitted the light, and prevented the communication of explosion.

VI. *Plan of an Extended and Practical Course of* LECTURES *and* DEMONSTRATIONS *on* CHEMISTRY, *to be delivered in the Laboratory of the Royal Institution. By* WILLIAM THOMAS BRANDE, *Fellow of the Royal Societies of London and Edinburgh, Professor of Chemistry in the Royal Institution, and of Chemistry and Materia Medica to the Apothecaries Company.*

THESE Lectures commence early in October, at nine in the morning, and are continued every Tuesday, Thursday, and Saturday.

Two Courses are given during the Season, which begins in October and terminates in May.

The Subjects comprehended in the Courses are treated of in the following order:

Division I. Of the Powers and Properties of Matter, and the General Laws of Chemical Changes.

§ 1. Attraction—Crystallization—Chemical affinity—Laws of Combination and Decomposition.

§ 2. Light and Heat—Their influence as Chemical Agents in art and nature.

§ 3. Electricity—Its Laws and connexion with Chemical phenomena.

Division II. Of Undecompounded S bstances and their Mutual Combinations.

§ 1. Substances that support Combustion, Oxygen, Chlorine, Iodine.

§ 2. Inflammable and acidifiable Substances—Hydrogen—Nitrogen—Sulphur—Phosphorus—Carbon—Boron.

§ 3. Metals—and their Combinations with the various Substances described in the earlier part of the Course.

Division III. Vegetable Chemistry.

§ 1. Chemical Physiology of Vegetables.

§ 2. Modes of Analysis—Ultimate and proximate Elements.

§ 3. Processes of Fermentation, and their products.

Division IV. Chemistry of the Animal Kingdom.

§ 1. General views connected with this department of the Science.

§ 2. Composition and properties of the Solids and Fluids of Animals—Products of Disease.

§ 3. Animal Functions.

Division V. Geology.

§ 1. Primitive and secondary Rocks—Structure and situation of Veins.

§ 2. Decay of Rocks—Production of Soils—Their analysis and principles of Agricultural improvement.

§ 3. Mineral Waters—Methods of ascertaining their contents by Tests and by Analysis.

§ 4. Volcanic Rocks—Phenomena and Products of Volcanic eruptions,

In the First Division of each Course, the principles and objects of Chemical Science, and the general Laws of Chemical Changes are explained, and the phenomena of Attraction, and of Light, Heat, and Electricity developed, and illustrated by numerous experiments.

In the Second Division, the undecompounded bodies are examined, and the modes of procuring them in a pure form, and of ascertaining their chemical characters exhibited upon an extended scale. The Lectures on the Metals include a succinct account of Mineralogy, and of the methods of analysing and assaying Ores.

This part of the Courses will also contain a full examination of Pharmaceutical Chemistry; the Chemical Processes of the Pharmacopœiæ will be particularly described, and compared with those adopted by the Manufacturer.

The Third and Fourth Divisions relate to Organic Substances. The Chemical Changes induced by Vegetation are here inquired into; the principles of Vegetables, the theory of Fermentation, and the characters of its products are then examined.

The Chemical History of Animals is the next object of inquiry: it is illustrated by an examination of their component parts, in health and in disease; by an inquiry into the Chemistry of the Animal Functions, and into the application of Chemical principles to the treatment of Diseases.

The Courses conclude with an Account of the Structureof the Earth, of the changes which it is undergoing, of the objects and uses of Geology, and of the principles of Agricultural Chemistry.

The applications of Chemistry to the Arts and Manufactures, and to economical purposes, are discussed at some length in various parts of the Courses. and the most important of them are experimentally exhibited.

Further particulars may be obtained by applying to Mr. Brande or to Mr. Fincher at the Royal Institution, 21, Albemarle-street.

[In consequence of the numerous communications received for this Number, it has been necessary to postpone the insertion of some not requiring immediate publication. It is requested that all communications may be addressed to Mr. Brande, at the Royal Institution, 21, Albemarle-street.]

Art. XXII. Meteorological Diary for the Months of March, April, and May, 1816, kept at Earl Spencer's Seat at Althorp, in Northamptonshire. The Thermometer hangs in a north-eastern aspect, about five feet from the ground, and a foot from the wall.

METEOROLOGICAL DIARY

for March, 1816.

		Thermometer.		Barometer.		Wind.	
		Low.	High.	Morn.	Even.	Morn.	Even.
Friday	1	24	38	29,75	29,70	W	SSW
Saturday	2	28,5	40	29,47	29,20	S	SE
Sunday	3	35	42	29,17	29,04	N	SE
Monday	4	30	44	29,06	29	W	W
Tuesday	5	26	42,5	29,03	29,06	W	WSW
Wednesday	6	31	43	28,81	28,81	WbN	SE
Thursday	7	31	47	28,93	29	SW	SW
Friday	8	32	42,5	29	28,98	S	NE
Saturday	9	32	39,5	29,20	29,40	NE	NE
Sunday	10	27	40	29,60	29,70	NW	W
Monday	11	25,5	50	29,70	29,48	SW	WSW
Tuesday	12	40	52	29,50	29,38	SW	SW
Wednesday	13	24	52,5	29,46	29,69	SW	W
Thursday	14	34	49	29,72	29,40	S	WbS
Friday	15	42	49	29,10	29,48	WSW	WbS
Saturday	16	25,5	45	29,65	29,60	W	E
Sunday	17	27	43,5	29,63	29,51	W	SW
Monday	18	33,5	48	29,42	29,42	SW	WbS
Tuesday	19	35	45	29,45	29,55	W	W
Wednesday	20	33,5	45	29,82	29,87	NW	N
Thursday	21	28,5	47,5	29,87	29,87	NW	SW
Friday	22	39	46	29,89	29,94	SW	S
Saturday	23	39	46,5	30,05	30,12	E	E
Sunday	24	28,25	42	30,19	30,12	EbS	E
Monday	25	33	39,5	30,03	29,88	E	E
Tuesday	26	35	40,5	30	30,02	NE	ENE
Wednesday	27	34	40	30,05	30,04	E	ENE
Thursday	28	31,5	41	30,04	30	E	E
Friday	29	31	41,5	30	30,03	E	E
Saturday	30	24	41,5	30,06	30,07	E	E
Sunday	31	33	44,5	30,09	30,04	ESE	E

METEOROLOGICAL DIARY

for April, 1816.

		Thermometer.		Barometer.		Wind.	
		Low.	High.	Morn.	Even.	Morn.	Even.
Monday	1	26,5	49	29,99	29,80	EbS	SE
Tuesday	2	29,5	48	29,71	29,66	EbN	E
Wednesday	3	28	44	29,70	29,74	E	EbS
Thursday	4	30	48,5	29,85	29,85	E	EbN
Friday	5	27	51	29,88	29,70	NE	SSE
Saturday	6	31	51,5	29,53	29,30	WSW	W
Sunday	7	32	48,5	29,08	28,91	W	W
Monday	8	33	45	28,96	29,03	W	WNW
Tuesday	9	29	46,5	29,12	29,16	ENE	NNE
Wednesday	10	37	50	29,08	29,22	NNE	E
Thursday	11	34	47	29,40	29,40	ENE	E
Friday	12	42	45	29,53	29,57	WNW	W
Saturday	13	34	39	29,64	29,60	NW	W
Sunday	14	28	38,5	29,44	29,44	NW	WbN
Monday	15	30	44	29,50	29,50	W	W
Tuesday	16	33	49	29,48	29,30	WSW	SW
Wednesday	17	40	51,5	29.27	29,37	W	W
Thursday	18	33	54,5	29,43	29,40	NE	SW
Friday	19	36	50,5	29,44	29,70	W	W
Saturday	20	28	54,5	29,90	29,85	WbN	SE
Sunday	21	36,5	56,5	29,66	29,60	E	E
Monday	22	32	57	29,60	29,60	NE	NE
Tuesday	23	44	53	29,67	29,70	NE	NE
Wednesday	24	43	61	29,77	29,79	ENE	NE
Thursday	25	40	64,5	29,90	29,93	NE	NE
Friday	26	39	60,5	30,00	30,00	NE	ENE
Saturday	27	33	62,5	29,97	29,88	ENE	NE
Sunday	28	43	65,5	29,80	29,63	ESE	SE
Monday	29	44	60	29,50	29,47	WbS	SSW
Tuesday	30	47	56	29,46	29.46	ESE	W

METEOROLOGICAL DIARY

for May, 1816.

		Thermometer.		Barometer.		Wind.	
		Low.	High.	Mor.	Even.	Morn.	Even.
Wednesday	1	34	58	29,53	29,53	SW	S
Thursday	2	38	58,5	29,63	29,74	S	SW
Friday	3	36	58	29,80	29,80	W	W
Saturday	4	44	49,5	29,93	29,93	W	W
Sunday	5	44	54,5	29,74	29,60	S	W
Monday	6	44,5	54	29,70	29,85	W	NW
Tuesday	7	33	58	29,85	29,65	W	S
Wednesday	8	40	59	29,52	29,32	WbS	SSW
Thursday	9	42	56,5	29,38	29,49	W	N
Friday	10	39	47	29,43	29,10	E	NNW
Saturday	11	37	47	29,17	29,25	N	W
Sunday	12	33	46	29,23	29,31	NW	NNW
Monday	13	29,5	54,5	29,40	29,51	W	NE
Tuesday	14	29	60	29,67	29,68	W	SW
Wednesday	15	41	56	29,70	29,70	E	SE
Thursday	16	43	66	29,73	29,65	E	SE
Friday	17	49	68	29,62	29,62	SE	E
Saturday	18	40	49	29,69	29,69	E	NE
Sunday	19	42	53	29,72	29,73	NE	ENE
Monday	20	31,5	63	29,78	29,80	NE	ENE
Tuesday	21	33,5	61,5	29,82	29,80	E	E
Wednesday	22	41	57	29,80	29,79	ENE	NE
Thursday	23	40	61	29,81	29,81	NE	NE
Friday	24	44	54	29,79	29,72	N	NE
Saturday	25	47	58	29,68	29,68	W	W
Sunday	26	36	61	29,97	29,97	WNW	WbS
Monday	27	41	54,5	29,83	29,98	E	E
Tuesday	28	44	63	30,00	30,00	ESE	W
Wednesday	29	44	67	30,00	29,86	W	S
Thursday	30	46	65	29,79	29,79	W	WNW
Friday	31	45	62,5	29,76	29,73	NW	N

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